UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Silver Spring, Maryland 20910

CRUISE REPORT[1]

VESSEL: *Hi`ialakai*, Cruise HI-06-11 (Fig. 1)

CRUISE PERIOD: 1 September–4 October 2006

AREA OF OPERATION: Northwestern Hawaiian Islands (NWHI)

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED), Pacific Islands Fisheries Science Center, National Marine Fisheries Service (NMFS), NOAA, and their partner agencies conducted reef assessment/monitoring studies in waters surrounding the Northwestern Hawaiian Islands. All activities described in this report were covered by the following permits: DLNR.NWHI06R017, DLNR.NWHI06R019, NWHIMNM-2006-011, NWHIMNM-2006-012, USFWS 12521-06043, USFWS 12521-06044, USFWS 12521-06045, USFWS 12521-06046, USFWS 12521-06047, USFWS 12521-06048.

ITINERARY:

1 September — Start of cruise. Embarked Bernardo Vargas Angel (corals), Jean Kenyon (corals), Peter Vroom (algae), Bonnie De Joseph (algae), Jason Leonard (permanent stake pounder), Jill Zamzow (fish), Paul Murakawa (fish), John Mitchell (fish), Brian Zgliczynski (fish towboard), Stephane Charette (fish towboard), Edmund Coccagna (benthic towboard), Jake Asher (benthic towboard), Jamison Gove (oceanography), Oliver Vetter (oceanography), Danny Merritt (oceanography), Michele Newlin (data manager), Andrea Rivera (data manager), James Maragos (permanent coral transects), Carl Meyer (sharks), Yannis Papastamatiou (sharks). Departed Snug Harbor at 0830 and transited to Pearl Harbor for fueling. Departed Pearl Harbor at 1830 and began transit to Necker Island (~400 nmi). An introductory meeting was held for all scientific personnel and new crew members at 1300, followed by a planning meeting for scientific personnel.

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2 September	Transit day. Jim Bostik (Dive Safety Officer) checked all scientist's dive gear and ran scientific personnel though injured diver drills. The Rapid Ecological Assessment (REA) team met with Keith Lyons (Coxswain) to discuss issues of working off HI-2. At 1200, Brian Zgliczynski held a dive safety meeting where medical and oxygen kits were discussed, and all dive gear was rinsed in a bleach solution. "Escape from Quarters" and abandon ship drills were held in the afternoon.
3 September	Arrived at Necker at 1200 and launched small boats for afternoon operations. The oceanography team recovered the Ocean Data Platform (ODP) plate and anchor, a Sea Surface Temperature (SST) buoy anchor, a subsurface temperature recorder (STR), and four coral recruitment plates (plus associated PVC pipes). The tow team completed four tows, circumnavigating the island at a 12.2-m isoboth and a 15.2-m isobath, and getting halfway around the island at an 18.3-m isobath. The REA Team completed two complete REA surveys and installed permanent transect pins at sites NEC-2 and NEC-4. Jim Maragos revisited a permanent coral transect (NEC-R6), and Carl Meyer searched for his shark receiver and ground tackle, but found them missing. All dive gear and field equipment were soaked in bleach solution after daily field operations. Began transit to French Frigate Shoals (FFS) at 1700 (with a dogleg to pump black water).
4 September	Conducted deepwater conductivity-temperature-depth (CTD) south of FFS at 0300. Arrived FFS in early morning and launched towed-diver team in the SafeBoat to retrieve Oliver Dameron from Tern Island ~0745. The tow team completed five tows: two around the northern forereef, one along the northern backreef, and two inside the lagoon. The oceanography team retrieved and deployed a coral reef early warning system (CREWS) buoy plus anchor and one STR. The REA team completed full surveys at sites FFS-30, FFS-21, and FFS-H6. Permanent transects were installed at FFS-30 and FFS-H6. A permanent transect installed by Greta Aeby was used at FFS-21. Jim Maragos revisted two of his permanent coral transects (11P and 16P). Carl Meyer recovered, downloaded, and redeployed two shark receivers. All dive gear and field equipment were soaked in bleach solution after daily field operations.
5 September	Continued work at FFS. The towed-diver team completed five full tows and one partial tow: two southeast forereef, two southeast backreef, two lagoon (one full and one partial). The oceanography team retrieved and replaced four STRs, and placed one new STR at REA site FFS-12. Two Ecological Acoustic Recorders (EARs)

were also deployed: one at REA site FFS-12 and one close to Jim Maragos's permanent transect 16P (near CREWS buoy). The REA team completed three full REA surveys at sites FFS-12, FFS-34, and FFS-R29. Permanent transects were installed at FFS-34 and FFS-R29; a transect created by Greta Aeby was used at FFS-12. Jim Maragos revisted one of his permanent coral transects (2P). Carl Meyer recovered, downloaded, and redeployed one shark receiver. All dive gear and field equipment were soaked in bleach solution after daily field operations. A fish aggregating device (FAD) with a large "Z" on it was found ensnared on a patch reef at N23 43.3919, W166 03.9502, but no action was taken to remove it. Began transit to Maro Reef via Gardner Pinnacles.

6 September — Arrived at Gardner Pinnacles ~0830. Deployed HI-2 with Vetter, Dameron, Meyer, Papastamatiou, Rivera, Newlin, and Woods (medical officer). Members of the oceanography team retrieved and deployed an STR; members of the shark team deployed a shark receiver, and data managers snorkeled. All dive gear and field equipment were soaked in bleach solution after daily field operations. Departed for Maro Reef. Members of the towed-diver team spent much of the transit trying to repair a crack that formed in the SafeBoat.

7 September — The *Hi`ialakai* conducted a deepwater CTD south of Maro Reef ~0300. Arrived Maro Reef in early morning for day operations. The tow team completed four full tows and one partial tow towards the northern portion of the reef system. The repaired SafeBoat leaked less than during operation on September 5, but additional repairs will be made during evening hours. The oceanography team retrieved and deployed a CREWS buoy and associated anchor, swapped a Seabird-39 STR, conducted four shallow water CTDs and one water sample profile. The REA team completed three full surveys at sites MAR-R1, MAR-R3, and MAR-R12. Greta Aeby's permanent transect was used at MAR-12, and a new permanent transect was installed at MAR-R3. Because MAR-R1 was a replacement site for MAR-R9 (the current at MAR-R9 was too strong to work); it was not included in initial permit requests, and no permanent transect was installed. Jim Maragos revisted two of his permanent coral transects (Rrm4 and 15P), and Carl Meyer recovered, downloaded, and redeployed a shark receiver at the northern tip of Maro. All dive gear and field equipment were soaked in bleach solution after daily field operations.

8 September — Continued work at Maro Reef. The towed diver team only completed three tows (two forereef and one lagoonal area) because of problems with the hydraulic steering unit in the SafeBoat. The

SafeBoat was brought on board the *Hi`ialakai* in the early afternoon to begin repair. The oceanography team retrieved and replaced two STRs, and put in an additional STR at REA site R12. They also conducted seven shallow water CTDS and two water sampling profiles. The REA team completed three full surveys at sites MAR-22, MAR-6, and MAR-8. A permanent transect was installed at MAR-6. Greta Aeby's transects at MAR-22 and MAR-8 were found and used. Carl Meyer fixed the ground tackle at the shark receiver deployed on September 7 and recovered the ground tackle from a missing receiver located towards the southern end of Maro. A new receiver and accompanying ground tackle were redeployed at this site. All dive gear and field equipment were soaked in bleach solution after daily field operations.

9 September — Continued work at Maro Reef. Conducted a deepwater CTD at 0300. The oceanography team completed four shallow water CTDs and two water sample profiles. The tow team completed five tows in the southeastern section of the reef. The REA team completed three full surveys at MAR-R5, MAR-31, and MAR-32. REAs were attempted at sites MAR-R6 and MAR-R8, but confused seas and currents kept divers out of the water at these locations. A permanent transect was installed at MAR-R5, but no permanent transects were installed at MAR-31 or MAR-32 since they were not listed on our permits. Jim Maragos surveyed a permanent coral transect at Rrm4, and Carl Meyer scouted out a site on the southwestern side of Maro for a possible future shark receiver. All dive gear and field equipment were soaked in bleach solution after daily field operations. Began transit to Laysan Island. The oceanography team cleaned the wet lab with bleach solution.

10 September — Conducted a deepwater CTD south of Laysan Island ~0100. Arrived Laysan Island for day operations. The oceanography team retrieved and replaced three STRs and one SST, conducted six shallow water CTDs and one water sample profile. The tow team completed six tows, fully circumnavigating the island. The REA team completed three full surveys at LAY-5, LAY-R12, and LAY-R9. Permanent transects were installed at all three sites. Carl Meyer deployed two new shark receivers, and Jim Maragos resurveyed two permanent coral transects. All dive gear and field equipment were soaked in bleach solution after daily field operations. Departed for Pearl and Hermes Atoll.

11 September — Transit day. The benthic REA team cleaned the web lab with bleach solution. A man overboard drill occurred in the afternoon.

12 September — Conducted two deepwater CTDs south of Pearl and Hermes Atoll. Arrived at Pearl and Hermes Atoll in early morning to begin field operations. The oceanography team swapped out one CREWS buoy and associated anchor and one STR. They also conducted five shallow water CTDs. The towed-diver team completed six tows in the southeastern section of the atoll: two backreef sites, and four forereef sites. Full REA surveys were completed at PHR-R32, PHR-R31, and PHR-R26. Greta Aeby's permanent transect was used at PHR-R32. New permanent transects were installed at PHR-R31 and PHR-R26. Carl Meyer retrieved three shark receivers, and Jim Maragos surveyed three U.S. Fish and Wildlife Service (USFWS) permanent coral transects: 6P, 9P, and 12P. All dive gear and field equipment were soaked in bleach solution after daily field operations.

13 September — Conducted a deepwater CTD south of the atoll at 0500. Continued day operations at Pearl and Hermes Atoll. The oceanography team swapped out three STRs, deployed two new STRs, and deployed five temporary STRs to assess possible upwelling events on the south side of the atoll that will be recollected before departing Pearl and Hermes. The oceanography team also deployed a temporary acoustic Doppler current profiler (ADCP), one EAR, and conducted five shallow water CTDs. The towed-diver team completed six tows on the southwest corner of the atoll: three forereef and three backreef. The REA team conducted three full surveys at PHR-R42, PHR-31, and PHR-30. Permanent transects were installed at PHR-R42 and PHR-30. A transect installed by Greta Aeby was surveyed at PHR-31. Carl Meyer retrieved three shark receivers, and Jim Maragos resurveyed a permanent USFWS coral transect at 7P. All dive gear and field equipment were soaked in bleach solution after daily field operations.

14 September — North shore sites were originally selected as our area of operation today, but 12-foot swells from the northeast blocked out the entire northern portion of the atoll. Operations shifted to other areas. The oceanography team swapped three STRs, conducted eight shallow water CTDs, and collected four water sample profiles. The towed-diver team completed five tows on the eastern forereef. The REA team conducted full surveys at PHR-33 and PHR-32 and complete fish and coral surveys with a qualitative algal survey at PHR-22. Permanent transects were installed at PHR-33 and PHR-22. A transect installed by Greta Aeby was located and used at PHR-32. Carl Meyer and Jim Maragos conducted reconnaissance dives and located colonies of *Acropora* on the southwestern forereef. This is the first report of *Acropora* from Pearl and Hermes Atoll. All dive gear and field equipment were soaked in bleach solution after daily

	field operations. The towed-diver team cleaned the web lab with bleach solution. Departed for Midway Atoll.
15 September	Conducted one deepwater CTD south of Midway Atoll at ~0300. Arrived at Midway Atoll in early morning. The oceanography team collected coral recruitment plates from around the SST anchor and then swapped both the SST and its anchor with new equipment. The oceanography team also swapped out five STRs. The towed-diver team completed six tows from the southeastern to southwestern corners of the atoll: five forereef tows and one backreef tow. The REA team completed full surveys at MID-2 and MID-R7. Complete fish and coral surveys were completed at MID-R3, but only a qualitative algal survey was conducted. Permanent transects were installed at all three sites. Carl Meyer retrieved two shark receivers from the south side of the atoll, and Jim Maragos resurveyed three USFWS coral transects: Rrm7, Rrm14, and 19P. All dive gear and field equipment were soaked in bleach solution after daily field operations.
16 September	Conducted one deepwater CTD south of Midway Atoll at ~0230. Continued work at Midway Atoll. The oceanography team swapped an ODP plate and placed an STR at REA site MID-R7. The towed-diver team completed five tows: one forereef, one lagoonal reef, and three backreefs. The REA team completed full surveys at MID-3 and MID-R25 and partial surveys at MID-R20 because of extremely high current from the northeastern swell washing over the backreef areas. Exisiting permanent transects were found and used at all three sites. The shark team redeployed the two southern shark receivers they retrieved on September 15 and fixed the accompanying ground tackle and retrieved the northern shark receiver. Jim Maragos resurveyed three permanent USFWS coral transects: 16P, 18P, and 20P. All dive gear and field equipment were soaked in bleach solution after daily field operations. The fish REA team cleaned the web lab with bleach solution. Departed for Kure Atoll.
17 September	Conducted one deepwater CTD south of Kure Atoll at ~0300. Arrived at Kure Atoll for morning operations. The oceanography team swapped out one CREWS buoy and associated anchor, one SST buoy and associated anchor, and two STRs. The towed-diver team completed six tows: three southern fore reef, one channel, one southern backreef, and one central lagoon. The REA team surveyed KUR-12, KUR-2, and KUR-14. Permanent transects were installed at KUR-12 and KUR-2. A transect previously installed by Greta Aeby was located and surveyed at KUR-14. Carl Meyer retrieved three shark receivers. Retrieved outboard

motors from Green Island field party and transferred to *Hi`ialakai*. All dive gear and field equipment were soaked in bleach solution after daily field operations.

18 September — Continued work at Kure Atoll. The oceanography team swapped out one STR and two wave and tide recorders (WTRs). Two additional STRs were placed at the WTR sites. One EAR was also deployed. The tow-diver team completed four tows along the northern forereef and two tows along the northern backreef. The REA team completed full surveys at KUR-R33, KUR-R36, and KUR-17. Permanent transects were installed at KUR-R33 and KUR-R36. A transect previously installed by Greta Aeby was located at KUR-17. Carl Meyer redeployed three shark receivers and fixed associated ground tackle. All dive gear and field equipment were soaked in bleach solution after daily field operations.

19 September — Continued work at Kure Atoll. The oceanography team circumnavigated the exterior of the atoll conducting 13 shallow water CTDs and 5 water sample profiles. The towed-diver team completed a single tow along the eastern backreef and conducted a series of drop dives on the southern forereef. The REA team completed full surveys at KUR-18 and KUR-9 and completed fish and coral surveys with a qualitative algal survey at KUR-R35. Permanent transects were installed at all three sites. Field equipment from Green Island was transported to the *Hi`ialakai* throughout the day, and the Department of Land and Natural Resources (DLNR) Green Island shore party (Vanderlip, McGuire, Marie, Karczmarski, and Morisaka) was picked up and brought to the *Hi`ialakai* at 1700. All dive gear and field equipment were soaked in bleach solution after daily field operations. The data management team cleaned the web lab with bleach solution. Departed for Midway Atoll.

20 September — Arrived Midway Atoll ~0300. At 0800, the *Hi`ialakai* pulled into the main channel and launched the two 19-ft SafeBoats. The *Hi`ialakai* docked by the fuel pier. Barry Christensen, the USFWS Refuge Manager, gave an introduction to Midway, and the scientific party was given the day ashore. Personal gear from the Kure Atoll party was brought ashore. Disembarked Vanderlip, McGuire, Marie, Karczmarski, and Morisaka. All ship and scientific personnel were required to be back on board by 1930 unless accompanied by the Refuge Manager. No alcohol consumption by the scientific crew was permitted, although the ship's crew was able to drink. The commanding officer, medical

officer, chief scientist, and USFWS representative were invited to dine with the Refuge Manager and his wife in the evening.

21 September — Continued work at Midway Atoll. The oceanography team moved the ODP about 3 meters into a better location, then completed 12 CTDs and 4 shallow water sample profiles. The towed-diver team finished four tows: two eastern backreef and two southern forereef tows. The REA site completed full fish and coral surveys and partial algal surveys (no photographs taken, but algal rankings completed) at MID-1, MID-H21, and MID-H11. Greta Aeby's transect was relocated and used at MID-1; permanent transects were installed at MID-H21 and MID-H11. Carl Meyer redeployed his northern shark receiver, and Jim Maragos surveyed USFWS coral transects 1A, 1C, 2, and 17P. All dive gear and field equipment were soaked in bleach solution after daily field operations. The shark/USFWS coral team cleaned the web lab with bleach solution. Departed for Pearl and Hermes Atoll.

22 September — Arrived at Pearl and Hermes Atoll and continued work. A heavy northeast swell prevented boat launching and work north of the atoll in the morning. The oceanography team recovered five temporary STRs and a temporary ADCP from the south side of the atoll. An ODP was deployed at this same spot. Three STRs were deployed on the north side of the atoll in the afternoon, one at REA site R39. Three shallow water CTDs and one water sample profile were also conducted on the north side. The towed-diver team completed five tows: two on eastern backreefs, two in the northern channel, and one on the northern forereef. The towed-diver team also recovered a shark receiver located on the north side of the atoll for Carl Meyer. The REA team completed a full survey at PHR-34, but did not install a permanent transect. The fish team conducted a fish assemblage characterization at the site where the ODP was deployed, while the benthic team revisited PHR-31 to photodocument a possible new coral species and then visited a *Halophila hawaiiana* seagrass meadow on the southeast side of the backreef. Carl Meyer and Jim Maragos conducted reconnaissance dives on the southwest side of the forereef and documented a second species of *Acropora* at Pearl and Hermes Atoll. All dive gear and field equipment were soaked in bleach solution after daily field operations.

23 September — Continued work at Pearl and Hermes Atoll. The oceanography team completed four shallow water CTDs and two water sample profiles (two duplicates at the same location). They also conducted a dive on the *Casitas* grounding site to check out the feasibility of an REA survey, but reported heavy swell and

breaking waves. The towed-diver team completed one northern backreef tow, one lagoonal tow, and two north to northeast forereef tows. The REA team surveyed PHR-R39, PHR-R44, and PHR-24. Permanent transects were installed at PHR-R39 and PHR-24. An Aeby transect was located and used at PHR-R44. Carl Meyer redeployed a receiver at his northern site. All dive gear and field equipment were soaked in bleach solution after daily field operations. Began transit to Lisianksi Island/Neva Shoals.

24 September — Transit day. The oceanography team cleaned the web lab with bleach solution. Arrived south of Lisianski Island/Neva Shoals in late afternoon. Conducted two deepwater CTDs and water sample profiles.

25 September — Began work at Lisianski Island/Neva Shoals. The oceanography team swapped out one SST buoy plus associated anchor and two STRs. One additional STR was deployed at REA site LIS-16, and coral recruitment plates were retrieved from the old CREWS buoy anchor. The towed-diver team completed five tows moving counterclockwise around the island from the northeast to the northwest to the west. The REA team surveyed LIS-R14, LIS-12, and LIS-R9. Permanent transects were installed at all three sites. Carl Meyer deployed one shark receiver at the northern end of the shoal system, and Jim Maragos repaired and surveyed permanent USFWS coral transects 1P, 6P, and 9P. All dive gear and field equipment were soaked in bleach solution after daily field operations.

26 September — Continued work at Lisianksi Island/Neva Shoals. The oceanography swapped out instrumentation on two WTRs and deployed new STRs at both WTR sites. They also conducted 19 shallow water CTDs and 4 water sample profiles. The towed-diver team completed five tows: two on the east side, one on the southeast corner, one on the southwest corner, and one on the west side. Species of *Acropora* were observed at Lisianski Island for the first time. The REA team surveyed LIS-16, LIS-17, and LIS-18 and installed permanent transects at each site. Carl Meyer deployed one new shark receiver at the southern end of Neva Shoals. All dive gear and field equipment were soaked in bleach solution after daily field operations.

27 September — Continued work at Lisianski Island/Neva Shoals. The oceanography team retrieved a CREWS buoy anchor from the southern end of Neva Shoals. The towed-diver team completed two tows: one on the western bank and one on the leeward side of Lisianski Island. The REA team surveyed LIS-R7, LIS-R10, and

	LIS-10, and installed permanenet transects at each site. Carl Meyer and Jim Maragos conducted a 30-meter dive on the southern end of Neva Shoals and found four new records of corals. They then conducted an additional dive on the southeast side of the forereef and documented two new records of *Acropora*, one of which may be an endemic undescribed species to the NWHI. All dive gear and field equipment were soaked in bleach solution after daily field operations. Began transit to FFS.
28 September	Continued transit to FFS. The benthic REA team cleaned the web lab with bleach solution.
29 September	Continued transit to FFS.
30 September	Arrived at FFS and continued field work. The oceanography team completed 25 CTDs and 5 water sample profiles. The towed-diver team completed five tows: one in the central lagoon, one on the east backreef, and three on northeast forereefs. The REA team completed full surveys at FFS-R46, FFS-32, and FFS-33. A permanent transect installed by Jim Maragos was relocated at FFS-R46, repaired, and resurveyed. New permanent transects were installed at FFS-32 and FFS-33. Carl Meyer retrieved two shark receivers, one from near La Persouse Pinnacle and one from near East Island. Jim Maragos resurveyed one USFWS coral transect (P3). All dive gear and field equipment were soaked in bleach solution after daily field operations.
1 October	Continued work at FFS. A large north swell coupled with strong winds from the south hindered operations. The oceanography team moved the EAR deployed on September 5 at REA site FFS-12 to Rapture Reef. The towed-diver team completed tows at three lagoonal sites. The REA team was not able to survey northern backreef and patch reef sites because of weather conditions. Full surveys were instead conducted at FFS-35. No permanent transect was installed. Carl Meyer redeployed two shark receivers, one near La Perouse Pinnacle and the other near East Island. All dive gear and field equipment were soaked in bleach solution after daily field operations. Began transit to Honolulu.
2 October	Continued transit to Honolulu.
3 October	Continued transit to Honolulu. The towed-diver team cleaned the web lab with bleach solution.
4 October	Arrived in Honolulu. Disembarked Vargas Angel, Kenyon, Vroom, De Joseph, Leonard, Zamzow, Murakawa, Mitchell,

Zgliczynski, Charette, Coccagna, Asher, Gove, Vetter, Damerson, Merritt, Newlin, Rivera, Maragos, Meyer, and Papastamatiou.

Table 1: Cruise statistics for NOWRAMP 2006.

	Necker Island	French Frigate Shoals	Gardner Pinnacles	Maro Reef	Laysan Island	Pearl and Hermes Atoll	Midway Atoll	Kure Atoll	Lisianski Island/ Neva Shoals
Towed-diver Habitat/Fish Surveys	4	19	0	13	6	26	15	13	12
Combined tow lengths (km)	7.48	45.37	0	28.49	13.33	67.25	37.49	29.29	30.47
Fish Rapid Ecological Assessments	2	10	0	9	3	13	9	9	9
Benthic Rapid Ecological Assessments	2	10	0	9	3	13	9	9	9
Permanent Coral Transects Monitored (Maragos)	1	4	0	3	2	4	10	0	3
Wave and Tide Recorders (WTR) recovered	0	0	0	0	0	0	0	2	2
Wave and Tide Recorders (WTR) deployed	0	0	0	0	0	0	0	2	2
Ocean Data Platforms (ODP) recovered	1	0	0	0	0	0	1	0	0
Ocean Data Platforms (ODP) deployed	0	0	0	0	0	1	1	0	0
SST buoys recovered *anchor recovered without SST buoy	0*	0	0	0	1	0	1	1	1
SST buoys deployed	0	0	0	0	1	0	1	1	1
STRs recovered	1	6	1	3	3	12	5	3	2
STRs deployed	0	7	1	4	3	17	6	5	5
CREWS buoys recovered *anchor recovered without CREWS buoy	0	1	0	1	0	1	0	1	0*
CREWS buoys deployed	0	1	0	1	0	1	0	1	0
Shallow water sample profiles taken (1 profile consists of chlorophyll and nutrient samples at 1 to 4 depths as depth allows, and a microbiota sample at the shallowest depth)	0	5	0	5	1	7	4	5	4
Deepwater sample profiles collected (5 samples per profile)	1	4	0	2	1	7	3	2	4
Deepwater CTDs (from *Hi`ialakai*)	1	4	0	2	1	7	3	2	4
Shallow water CTDs	0	25	0	15	6	25	12	13	19

	Necker Island	French Frigate Shoals	Gardner Pinnacles	Maro Reef	Laysan Island	Pearl and Hermes Atoll	Midway Atoll	Kure Atoll	Lisianski Island/ Neva Shoals
Multibeam mapping (sq. km)	0	0	0	0	0	0	0	0	0
Shark receivers recovered *ground tackle recovered but shark receiver missing	0	5	0	1+0*	0	4	3	3	0
Shark receivers deployed	0	3	1	2	2	4	3	3	2
SCUBA dives	39	176	4	135	47	206	107	134	131

MISSIONS:

A. Conduct ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (<35 m) coral reef ecosystems of the NWHI.

B. Deploy an array of CREWS buoys, SST buoys, subsurface ODPs, subsurface WTRs, and STRs to allow remote long-term monitoring of oceanographic and environmental conditions affecting coral reef ecosystems of the NWHI.

C. Collect water samples for analysis of nutrient and chlorophyll levels.

D. Conduct shipboard CTDs to a depth of 500 m, shallow water CTDs from small boats to a depth of ~30 m, and shipboard ADCP surveys around reef ecosystems to examine physical and biological linkages supporting and maintaining these island and atoll ecosystems.

E. Determine the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.

F. Collect ADCP data during all transits. The ADCP unit shall be configured to collect narrow-band data in 16 meter bins (deepwater mode).

RESULTS:

A. Ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (<35 m) coral reef ecosystems of the NWHI was completed at 64 sites.

B. Four CREWS buoys, 4 SST buoys, 2 subsurface ODPs, 4 subsurface WTRs, and 48 STRs were deployed to allow remote long-term monitoring of oceanographic

and environmental conditions affecting coral reef ecosystems of the NWHI. Four CREWS buoys, 4 SST buoys, 2 subsurface ODPs, 4 subsurface WTRs, and 36 STRs were recovered.

C. Thirty-one shallow water and 24 deep water stations were visited to collect water samples for analysis of nutrient and chlorophyll levels.

D. Twenty four shipboard CTDs to a depth of 500 m, and 115 shallow water CTDs from small boats to a depth of ~30 m, were completed.

E. The existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris were noted.

F. ADCP data was collected during all transits.

SCIENTIFIC PERSONNEL:

Peter Vroom, PhD, Chief Scientist, Benthic Team – Algae, University of Hawaii (UH)-Joint Institute for Marine and Atmospheric Research (JIMAR), Pacific Islands Fisheries Science Center (PIFSC)-Coral Reef Ecosystems Division (CRED)
Jill Zamzow, PhD, Fish Team, State of Hawaii Department of Land and Natural Resoures, Division of Aquatic Resources (DLNR-DAR)
Paul Murakawa, Fish Team, DLNR-DAR
John Mitchell, PhD, Fish Team, DLNR-DAR
Jason Leonard, Fish Team, DLNR-DAR
Bernardo Vargas Angel, PhD, Benthic Team – Coral Disease, UH-JIMAR, PIFSC-CRED
Jean Kenyon, PhD, Benthic Team - Corals, UH-JIMAR, PIFSC-CRED
James Maragos, PhD, top predator/coral team – Corals, United States Fish and Wildlife Service (USFWS)
Andrea Rivera, Data Manager, UH Manoa
Bonnie De Joseph, Benthic Team – Algae, UH-JIMAR, PIFSC-CRED
Brian Zgliczynski, Towed diver – fish, UH-JIMAR, PIFSC-CRED
Stephane Charette, Towed diver – fish, UH-JIMAR, PIFSC-CRED
Jacob Asher, Towed diver – habitat, UH-JIMAR, PIFSC-CRED
Edmund Coccagna, Towed diver – habitat, UH-JIMAR, PIFSC-CRED
Daniel Merritt, Oceanography, UH-JIMAR, PIFSC-CRED
Jamison Gove, Oceanography, UH-JIMAR, PIFSC-CRED
Oliver Vetter, Oceanography, UH-JIMAR, PIFSC-CRED
Oliver Dameron, Oceanography, UH-JIMAR, PIFSC-CRED
Michele Newlin, Data Manager, NOAA Coral Reef Information System (NOAA-CoRIS)
Carl Meyer, PhD, top predator/coral team - sharks, UH Manoa-Hawaii Institute of Marine Biology (HIMB)
Yannis Papastamatiou, top predator/coral team - sharks, UH Manoa-HIMB

DATA COLLECTED:

Digital “before and after” pictures of individual stakes installed for permanent REA transects
Digital images from algal photoquadrats
Algal voucher specimens necessary for algal species identification
Algal field notes of species diversity and relative abundance
Videotransects of benthos and overall site character at each site
Number of coral colonies, by species, within belt transects of known area, and overall coral colony density at each site
Qualitative assessment (DACOR) of coral species' relative abundance at each site
Size class distributions of corals (by species and overall) at each site
Digital images of diseased coral
Field notes on signs of coral bleaching or disease
Samples of diseased coral for histopathological analysis
Digital still photos of overall site character and typical benthos at each site
Transect surveys of all fish 2 cm or larger in 600 m^2 – ID to species and estimate size
Stationary point count surveys of fish 25 cm and larger – ID to species and estimate size
Fish species presence checklists for community diversity estimates at each site
Digital images of rare or interesting fish species
Digital images of the benthic habitat from towboard surveys
Macroinvertebrate counts from towboard surveys
Quantitative surveys of reef fishes (larger than 50 cm TL) to species level from towboards
Habitat lineation from towboard surveys
Benthic composition estimations from towboard surveys
Acoustic Doppler current profile (ADCP) data
Conductivity, temperature and depth (CTD) profiles to 500 m
Water Samples to 500 m: Chlorophyll and Nutrient - 5 depths per cast
Conductivity, Temperature, Depth (CTD) casts: 30 m
Shallow Water Samples (30 m): Chlorophyll and Nutrient - 4 depths per cast
Sea surface and subsurface temperature at variable depths
Sea surface and subsurface salinity at variable depths
Spectral wave energy and tidal elevation
Directional ocean currents
Solar radiation, air temperature, wind speed and direction, turbidity, and photosynethtic active radiation
Acoustic Doppler current profiler (ADCP) transects

(/s/Peter S. Vroom)

Submitted by: _____
Peter S. Vroom, Ph.D.
Chief Scientist

(/s/David Kennedy)

Approved by: _____
David Kennedy
Program Manager
Coral Reef Conservation Program

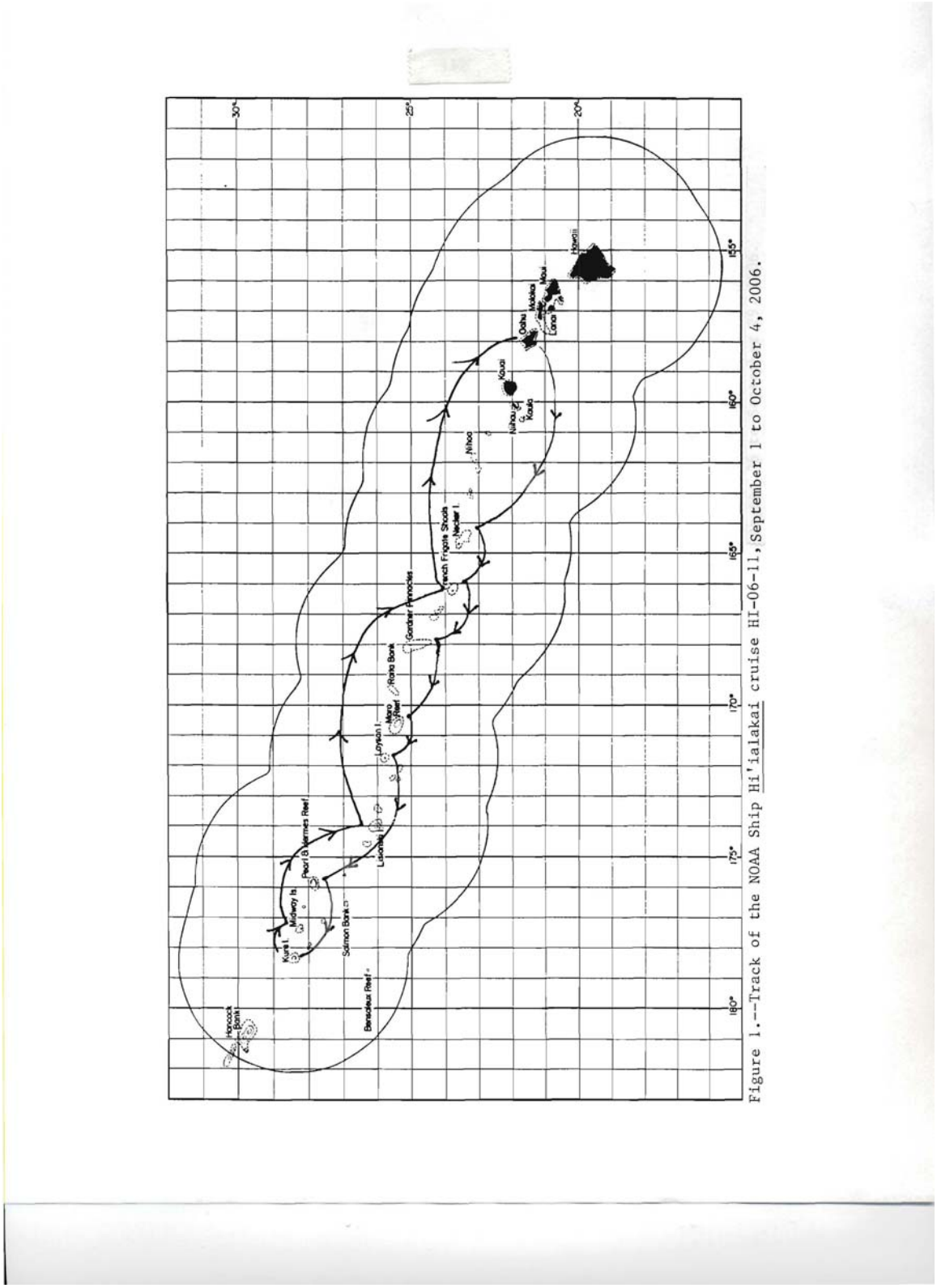

Figure 1.--Track of the *Hi`ialakai* HI-06-11, September 1 through October 4, 2006.

Appendix A: Methods

A.1 Oceanography and Water Quality Methods

(*Jamison Gove, Oliver Dameron, Oliver Vetter,and Daniel Merritt*)

Since 2001, the Coral Reef Ecosystem Division (CRED) has been conducting oceanographic research in the Northwestern Hawaiian Islands (NWHI) using established methods of recovery/redeployment of instrument platforms and oceanographic/water quality surveys of each of the islands and atolls. These methods monitor and assess important physical, chemical, and biological variables in the coral reef ecosystem. During HI0611, the oceanography team utilized these methods to monitor long-term trends and assess oceanographic conditions.

Since logistics constrain site visits to short periods every 2 years, long-term oceanographic monitoring is accomplished by deployment and retrieval of a variety of internally recording instrument platforms. These instrument platforms and their locations are listed in Table A.1.1. In the NWHI, these instruments include:

- Wave and Tide Recorders (WTR): Moored instruments which measure spectral wave energy, precision tidal elevation, and subsurface water temperature.
- Ocean Data Platforms (ODP): Moored instruments which measure subsurface temperature, salinity, directional spectral wave energy, precision tidal elevation, and current profiles.
- Coral Reef Early Warning System (CREWS) buoys: Surface buoys which measure solar radiation, air temperature, wind speed and direction, sea surface temperature, salinity, turbidity, and (on enhanced models) photosynethtic active radiation. CREWS buoys telemeter a portion of their collected data in near real time.
- Sea Surface Temperature (SST) buoys: Surface buoys which measure high resolution water temperature and telemeter their data in near real time.
- Subsurface Temperature Recorders (STR): Moored instruments which measure high resolution subsurface temperatures.
- Ecological Acoustic Recorders (EAR): Passive acoustic moored instruments which record the ambient sound field. This data is used both to monitor biotic sounds and boat traffic.

While at each site, detailed oceanographic and water quality surveys are accomplished with the following:

- Small vessel water sampling: Conductivity, temperature and depth (CTD) casts, including turbidity measurements, were performed to a maximum depth of 30 meters using an SBE 19+ at regularly spaced intervals around each island/atoll. Water quality profiles were conducted as a subset of the CTD casts using a hand deployed Niskin bottle string at depths of 30 m, 20 m, 10 m and 1 m as allowed by the depth at each cast site. Water samples were collected for nutrient and chlorophyll concentrations at each depth.

- Shipboard water sampling: CTD casts were performed to a depth of 500 meters and included flourometric (chlorophyll concentration) and dissolved oxygen measurements, from the *Hi'ialakai* using an SBE911. These casts were performed along ADCP (below) transects or independently. Water samples were collected from the majority of casts at 150 m, 125 m, 100 m, 80 m, 30 m and 3 m using Niskin bottles. Water samples were collected for nutrient and chlorophyll concentrations at each depth.
- Acoustic Doppler Current Profiler (ADCP) data provide information on oceanographic current structure from the surface to 600 m. ADCP transects were conducted in conjunction with deepwater CTDs around each of the islands as well as during transits and most other vessel activity.
- Continuous recording of surface and subsurface water temperatures as a function of depth were recorded during all towed-diver operations, providing a broad and diverse spatial and thermal sampling method.

EventDate	Event	StatusActive	HistoryID	PlatformRef	LocationRef	Location	PlatformType	SerialNum	Depth (m)	Lat2	Lon2
4/10/2005	Deployment	TRUE	1373	134	4	NWHI: Necker	ODP	267-002	24.9	23.57	-164.71
4/10/2005	Deployment	TRUE	1386	165	4	NWHI: Necker	SBE39	3929252-0907	17.07	23.57	-164.70
9/17/2004	Deployment	TRUE	1267	302	5	NWHI: French Frigate Shoals	SBE39	3936859-1566	3.96	23.77	-166.26
9/17/2004	Deployment	TRUE	1268	300	5	NWHI: French Frigate Shoals	SBE39	3936859-1564	2.01	23.74	-166.17
9/18/2004	Deployment	TRUE	1269	299	5	NWHI: French Frigate Shoals	SBE39	3936859-1563	1.83	23.62	-166.12
9/18/2004	Deployment	TRUE	1270	309	5	NWHI: French Frigate Shoals	SBE39	3936859-1569	7.9	23.86	-166.27
9/19/2004	Deployment	TRUE	1271	307	5	NWHI: French Frigate Shoals	SBE39	3936859-1567	2.1	23.87	-166.22
4/11/2005	Deployment	TRUE	1347	161	5	NWHI: French Frigate Shoals	SBE39	3929252-0906	1	23.86	-166.27
4/11/2005	Deployment	TRUE	1370	111	5	NWHI: French Frigate Shoals	CREWS-ENH	261-003	7.32	23.86	-166.27
9/20/2004	Deployment	TRUE	1272	301	6	NWHI: Gardner	SBE39	3936859-1565	10.36	25.00	-168.00
12/23/2004	Deployment	TRUE	1247	308	7	NWHI: Maro	SBE39	3936859-1568	8.53	25.45	-170.63
9/21/2004	Deployment	TRUE	1273	311	7	NWHI: Maro	SBE39	3936859-1642	1.83	25.38	-170.54
9/21/2004	Deployment	TRUE	1274	310	7	NWHI: Maro	SBE39	3936859-1641	4.27	25.37	-170.51
10/16/2005	Deployment	TRUE	1637	96	7	NWHI: Maro	CREWS-STD	262-002	8.83	25.45	-170.63
9/24/2004	Deployment	TRUE	1124	127	8	NWHI: Laysan	SST-ARGOS	306-022	3.3	25.77	-171.74
9/24/2004	Deployment	TRUE	1249	312	8	NWHI: Laysan	SBE39	3936859-1643	1.21	25.78	-171.74
9/24/2004	Deployment	TRUE	1250	313	8	NWHI: Laysan	SBE39	3936859-1644	0.91	25.76	-171.73
6/13/2005	Deployment	TRUE	1418	349	8	NWHI: Laysan	SBE39	3924022-0358	3.3	25.77	-171.74
10/9/2004	Deployment	TRUE	1157	326	9	NWHI: Lisianski	WTR (Wave & Tide Recorder)	26P36859-1032	23.46	26.10	-174.00
10/10/2004	Deployment	TRUE	1158	327	9	NWHI: Lisianski	WTR (Wave & Tide Recorder)	26P36859-1033	14.9	25.94	-173.88
10/9/2004	Deployment	TRUE	1264	237	9	NWHI: Lisianski	SBE39	3927005-0478	0.61	26.06	-173.96
10/10/2004	Deployment	TRUE	1265	235	9	NWHI: Lisianski	SBE39	3929086-0702	8.53	25.97	-173.92
6/14/2005	Deployment	TRUE	1419	345	9	NWHI: Lisianski	SST-ARGOS	306-029	10.7	25.97	-173.92
9/27/2004	Deployment	TRUE	1117	110	10	NWHI: Pearl and Hermes	CREWS-STD	280-003	7.9	27.85	-175.82
9/27/2004	Deployment	TRUE	1251	315	10	NWHI: Pearl and Hermes	SBE39	3936859-1646	0.61	27.96	-175.78
9/27/2004	Deployment	TRUE	1252	314	10	NWHI: Pearl and Hermes	SBE39	3936859-1645	7.9	27.85	-175.82
9/28/2004	Deployment	TRUE	1253	318	10	NWHI: Pearl and Hermes	SBE39	3936859-1649	1.83	27.90	-175.83
9/28/2004	Deployment	TRUE	1254	321	10	NWHI: Pearl and Hermes	SBE39	3936859-1652	1.5	27.80	-175.78
9/29/2004	Deployment	TRUE	1255	320	10	NWHI: Pearl and Hermes	SBE39	3936859-1651	23.16	27.78	-175.88
10/1/2004	Deployment	TRUE	1256	319	10	NWHI: Pearl and Hermes	SBE39	3936859-1650	2.4	27.91	-175.89

EventDate	Event	StatusActive	HistoryID	PlatformRef	LocationRef	Location	PlatformType	SerialNum	Depth (m)	Lat2	Lon2
10/4/2004	Deployment	TRUE	1159	137	11	NWHI: Midway	ODP	267-003	29.26	28.23	-177.43
10/2/2004	Deployment	TRUE	1257	316	11	NWHI: Midway	SBE39	3936859-1647	0.91	28.24	-177.32
10/2/2004	Deployment	TRUE	1258	291	11	NWHI: Midway	SBE39	3933179-1206	0.91	28.28	-177.37
10/2/2004	Deployment	TRUE	1259	293	11	NWHI: Midway	SBE39	3933179-1205	1.52	28.27	-177.39
10/2/2004	Deployment	TRUE	1260	322	11	NWHI: Midway	SBE39	3936859-1653	0.91	28.19	-177.40
7/1/2005	Deployment	TRUE	1482	348	11	NWHI: Midway	SBE39	3920707-0160	9.14	28.22	-177.34
6/29/2004	Deployment	TRUE	944	118	12	NWHI: Kure	SST-ARGOS	268-011	9.8	28.42	-178.34
10/5/2004	Deployment	TRUE	1079	112	12	NWHI: Kure	CREWS-STD	262-005	9.7	28.42	-178.34
10/6/2004	Deployment	TRUE	1155	298	12	NWHI: Kure	WTR (Wave & Tide Recorder)	26P36859-1030	14.9	28.39	-178.28
10/7/2004	Deployment	TRUE	1156	297	12	NWHI: Kure	WTR (Wave & Tide Recorder)	26P36859-1029	27.1	28.45	-178.36
10/5/2004	Deployment	TRUE	1261	230	12	NWHI: Kure	SBE39	3920707-0161	9.75	28.42	-178.34
10/7/2004	Deployment	TRUE	1262	234	12	NWHI: Kure	SBE39	3927172-0724	0.61	28.43	-178.37
10/8/2004	Deployment	TRUE	1263	236	12	NWHI: Kure	SBE39	3926520-0586	0.61	28.45	-178.31

Table A.1.1. Instrument platform and location for oceanographic monitoring devices in the NWHI before the start of HI-06-11 .

Table A.2.1 Established CRED and NWHIMNM long-term REA monitoring sites in the NWHI 2002-2005.

REA sites selected and surveyed for long-term monitoring by fish and benthic teams
Coordinates listed are from CRED 2003 surveys (except LAY-R11, 2004) or from Maragos/Aeby permanent transects where used

Transect depths are from CRED 2004 benthic surveys, or from Maragos/Aeby permanent transects; azimuth from 2005 Reserve surveys; NR = no record

NWHI long-term monitoring sites with Maragos permanent transect markers

Site #	most recent CRED survey date	Reserve 2005 survey date	Using Maragos Perm. Transect?	Using Aeby Perm. Transect?	Degree decimal minutes: Latitude (N) Degrees	Latitude (N) minutes	Longitude (W) Degrees	Longitude (W) minutes	Transect depth (ft)	Azimuth*	Degree decimal: Latitude	Longitude	Site #	Using Maragos Perm. Transect?
Necker													**Necker**	
R6	7/14/03	10/4/05	Rrm1		23	34.524	164	42.312	30		23.5754	-164.7052	R6	Rrm1
4	7/14/03	10/4/05			23	34.437	164	42.228	30	120	23.5740	-164.7038	4	
2	7/14/03	10/4/05			23	34.693	164	42.384	34	190	23.5782	-164.7064	2	
FFS													**FFS**	
H6	9/16/2004	9/18/05	5P		23	52.812	166	16.392	23-43		23.8802	-166.2732	H6	5P
21	9/16/2004	9/18/05		Yes	23	50.822	166	19.630	25	t1,130/t2,270	23.8470	-166.3272	21	
22	7/15/2003				23	51.933	166	14.381	NR	NR	23.8659	-166.2554	22	
R46	9/17/2004		P3		23	46.158	166	15.696	15-30		23.7693	-166.2616	R46	P3
32	9/17/2004	9/17/05			23	48.366	166	13.849	25-30	120	23.8061	-166.2308	32	
33	9/17/2004	9/17/05			23	50.142	166	15.952	25	80	23.8357	-166.2659	33	
34	9/19/2004	9/19/05			23	37.682	166	8.122	35	40	23.6280	-166.1354	34	
R29	9/19/2004	9/19/05			23	40.711	166	8.791	20-25	t1,95/t2,150	23.6785	-166.1465	R29	
12	9/19/2004	9/19/05		Yes	23	38.323	166	10.802	30	140	23.6387	-166.1800	12	
R30	9/18/2004				23	51.994	166	12.870	5	NR	23.8666	-166.2145	R30	
23	9/16/2004	9/17/05			23	51.943	166	14.382	5	200	23.8657	-166.2397	23	
30	9/18/2004	9/18/05		Yes	23	50.993	166	17.846	14	320	23.8499	-166.2974	30	

Site #	most recent CRED survey date	Reserve 2005 survey date	Using Maragos Perm. Transect?	Using Aeby Perm. Transect?	Degrees	minutes	Degrees	minutes	Transect depth (ft)	Azimuth*	Latitude	Longitude	Site #	Using Maragos Perm. Transect?
Gardner Pinnacles													**Gardner Pinnacles**	
R3	9/20/2004				24	59.812	167	59.929	54	NR	24.9969	-167.9988	R3	
R6	9/20/2004				25	0.028	168	0.068	57	NR	25.0005	-168.0011	R6	
						59.934					24.9989	-167.9998		
R5	9/20/2004		Rrm1		24		167	59.988	40-50'				R5	Rrm1
Maro													**Maro**	
R5	9/21/2004				25	22.091	170	30.102	24	NR	25.3682	-170.5017	R5	
R6	9/21/2004				25	20.471	170	30.032	38	NR	25.3412	-170.5005	R6	
R8	9/21/2004	9/20/05			25	20.053	170	31.514	45	10	25.3342	-170.5252	R8	
R12	9/22/2004	9/21/05		Yes	25	28.279	170	38.574	45	40	25.4713	-170.6429	R12	
R9	9/22/2004	9/21/05		Yes	25	27.671	170	40.994	60	90	25.4612	-170.6832	R9	
R3	9/22/2004	9/21/05			25	25.129	170	40.161	60	t1,80/t2,160	25.4188	-170.6694	R3	
8	9/23/2004	9/22/05		Yes	25	25.000	170	35.030	25	t1,225/t2,300	25.4167	-170.5838	8	
6	9/23/2004	9/22/05			25	23.892	170	34.439	20	20	25.3982	-170.5740	6	
22	9/23/2004	9/22/05		Yes	25	22.720	170	34.044	51	51	25.3787	-170.5674	22	
Laysan													**Laysan**	
5	7/23/2003				25	47.240	171	43.760	NR	NR	25.7873	-171.7293	5	
R12	9/24/2004				25	46.657	171	44.833	33-47	NR	25.7776	-171.7472	R12	
R9	9/24/2004				25	45.233	171	44.468	26-37	NR	25.7539	-171.7411	R9	
R11	9/24/2004				25	45.932	171	44.653	18-46	NR	25.7655	-171.7442	R11	
Lisianski													**Lisianski**	
10	10/10/2004				25	56.460	173	55.338	28-31	NR	25.9410	-173.9223	10	
R10	10/10/2004				25	56.675	173	57.212	37-46	NR	25.9446	-173.9535	R10	
R7	10/10/2004				25	57.227	173	58.234	34-38	NR	25.9538	-173.9706	R7	
16	10/11/2004				25	59.226	173	59.688	40	NR	25.9871	-173.9948	16	

17	10/11/2004				25	58.155	173	57.774	33-38	NR	25.9693	-173.9629	17	
R14	10/9/2004				26	4.692	173	59.822	48	NR	26.0782	-173.9970	R14	
12	10/9/2004				26	3.957	174	0.099	24-28	NR	26.0660	-174.0017	12	
R9	10/9/2004				26	2.368	174	0.746	26	NR	26.0395	-174.0124	R9	
18	10/11/2004				26	0.253	173	59.659	21-28	NR	26.0042	-173.9943	18	

Site #	most recent CRED survey date	Reserve 2005 survey date	Using Maragos Perm. Transect?	Using Aeby Perm. Transect?	Degrees	minutes	Degrees	minutes	Transect depth (ft)	Azimuth*	Latitude	Longitude	Site #	Using Maragos Perm. Transect?
Pearl & Hermes													**Pearl & Hermes**	
R39	9/27/2004	9/26/06			27	56.437	175	51.704	41-48	50	27.9406	-175.8617	R39	
26	9/27/2004	9/26/06	Yes		27	57.468	175	48.125	5	350	27.9578	-175.8021	26	Yes
24	9/27/2004	9/26/06			27	55.175	175	51.695	24-34	150	27.9196	-175.8616	24	
R44	9/30/2004		Yes		27	54.631	175	54.280	46	NR	27.9105	-175.9047	R44	Yes
R22	9/30/2004				27	53.952	175	54.897	11-16	NR	27.8992	-175.9150	R22	
23	7/30/2003				27	52.868	175	55.967	NR	NR	27.8811	-175.9328	23	
R26	9/26/2004	9/25/05			27	47.154	175	46.819	40	60	27.7859	-175.7803	R26	
R31	9/26/2004	9/25/05			27	49.605	175	47.518	34	150	27.8268	-175.7920	R31	
R32	9/26/2004	9/25/05	PH7	Yes	27	50.072	175	45.210	3	200	27.8345	-175.7535	R32	PH7
33	9/28/2004				27	47.138	175	49.393	40	NR	27.7856	-175.8232	33	
22	9/28/2004				27	47.723	175	51.990	6	NR	27.7954	-175.8665	22	
30	9/28/2004				27	46.761	175	53.710	9	NR	27.7794	-175.8952	30	
R42	9/29/2004	9/24/05			27	45.185	175	56.941	45	340	27.7531	-175.9490	R42	
31	9/29/2004	9/24/05		Yes	27	46.532	175	58.401	19	240	27.7755	-175.9734	31	
32	9/29/2004	9/24/05		Yes	27	46.351	175	56.370	21	120	27.7725	-175.9395	32	
Midway													**Midway**	
2	10/4/2004	9/27/05			28	11.843	177	20.765	38-43	70	28.1974	-177.3461	2	
H10	10/2/2004	9/27/05			28	12.908	177	25.504	40-45	350	28.2151	-177.4251	H10	
R7	10/4/2004	9/27/05			28	11.791	177	22.495	46-49	60	28.1965	-177.3749	R7	
3	8/6/2003		Rrm7		28	13.068	177	20.639	30		28.2178	-177.3440	3	Rrm7
R15	10/1/2004	9/28/05			28	14.223	177	23.687	5-9	80	28.2371	-177.3948	R15	

H11	8/6/2003				28	13.065	177	24.196	NR	NR	28.2178	-177.4033	H11	
R3	10/4/2004				28	11.420	177	23.972	36-51	NR	28.1903	-177.3995	R3	
R20	10/3/2004		17P		28	13.902	177	19.086	5-10		28.2317	-177.3181	R20	17P
R25	10/2/2004		19P		28	11.616	177	24.102	5-8		28.1936	-177.4017	R25	19P
H21	10/1/2004	9/28/05	Rrm13		28	16.650	177	21.978	8		28.2775	-177.3663	H21	Rrm13
1	10/1/2004	9/28/05		Yes	28	16.148	177	23.181	3	350	28.2691	-177.3864	1	

Site #	most recent CRED survey date	Reserve 2005 survey date	Using Maragos Perm. Transect?	Using Aeby Perm. Transect?	Degrees	minutes	Degrees	minutes	Transect depth (ft)	Azimuth*	Latitude	Longitude	Site #	Using Maragos Perm. Transect?
Kure													**Kure**	
12	10/6/2004	9/30/05			28	22.951	178	19.484	31-35	120	28.3826	-178.3253	12	
R33	10/5/2004	9/29/05			28	25.006	178	22.706	46-48	200	28.4163	-178.3778	R33	
17	10/7/2004	9/30/05		Yes	28	25.912	178	22.003	3	100	28.4319	-178.3667	17	
2	10/5/2004	9/29/05			28	27.218	178	20.626	31-50	50	28.4535	-178.3432	2	
18	10/7/2004		TBD*		28	25.087	178	20.649	18-24	NR	28.4180	-178.3444	18	TBD*
9	10/6/2004				28	24.346	178	20.537	14-18	NR	28.4058	-178.3423	9	
R36	10/5/2004	9/29/05			28	25.215	178	22.281	8	190	28.4206	-178.3715	R36	
14	10/7/2004	9/30/05		Yes	28	27.209	178	19.716	3	70	28.4535	-178.3286	14	
R35	10/6/2004				28	23.581	178	20.958	11-16	NR	28.3925	-178.3495	R35	

A.2 Rapid Ecological Assessment (REA) Methods

(Fish: Jill Zamzow, Paul Murakawa, Jason Leonard, and John Mitchell; Corals: Jean Kenyon and Bernardo Vargas Angel; Algae:Peter Vroom and Bonnie DeJoseph)

The survey methodology used during HI0611 is the same as previously used during REA surveys conducted in 2004, when long-term monitoring sites were selected and surveyed by the full REA team (Table A.2.1). During the 2006 NWHI Coral Reef Assessment and Monitoring Program (NOWRAMP) cruise, no invertebrate REA activities were conducted. At each REA site, three 25-m transect lines were laid out by the fish team, separated from each other by approximately 2–3 m. At most sites, transects were laid out at between 3–15 m depth. REA methods for each specific discipline are as follows.

A.2.1 Algae

Standardized quantitative sampling methods for remote tropical Pacific islands were developed and published for marine algae (Preskitt et al., Pacific Science 2004). To allow for vertical sampling in areas of high relief (walls), the method was modified slightly by Vroom et al. (in review, Coral Reefs) and entails photographing quadrats, collecting algal voucher specimens, creating in situ algal species lists, and ranking relative algal abundance. This modified "Preskitt method" has been used by CRED since 2003 in the Northwestern Hawaiian Islands, Guam/Mariana Islands, Pacific Remote Island Areas, and American Samoa.

Macroalgae were tentatively identified to genus in the field and ranked abundance of algal genera was collected from 12 quadrats (0.18 m^2) at each site (1 being the most abundant, 2 being the next most abundant, etc., with 10 being the maximum number of genera found in a single quadrat). Six quadrats were located at random points along the first two transects (3 per transect), and six quadrats were located at points 3-m perpendicular from each random point, in the direction of shallower water. Additionally, samples of macroalgae present within each quadrat were collected as voucher specimens (Preskitt et al., 2004) for microscopic analysis and species verification. A random swim at the end of each dive augmented macroalgal collections attained from quadrats and allowed cryptic species that predominantly occurred in shaded areas to be qualitatively recorded. Because of difficulties with identification, algae that fell within the functional groups of turf, cyanophytes, branching coralline algae, and crustose coralline algae were lumped into their respective categories. All ranked data were collected by the same individual to minimize the effects of observer bias.

A.2.2 Corals

At each site, the first two transect lines laid by the fish team served as the focal point for coral quantitative studies. Both transect lines were videotaped, including a 360^o pan at the beginning, middle, and end of each videosurvey. Then, working in the reverse direction along the transect lines, each coral whose center fell within one half meter of

either side of the transect line was assigned to a species and one of seven size classes: 1-5 cm, 6-10 cm, 11-20 cm, 21-40 cm, 41-80 cm, 81-160 cm, and >160 cm based upon a visual estimate of the identification and long diameter of each coral. For all but a few sites, corals were completely censused along both lines, but in some cases, time was not sufficient to complete the census. In these latter cases, the length of the lines actually censused was recorded and used to establish corrections to allow for comparisons with coral census data from other sites. The above data were used to compile generic richness, frequency of corals (no. per m^2), total number of colonies per taxon, proportion of total by taxon, and to plot the size distribution of corals at each site. Lastly, a larger area outside the belt transects was examined according to the amount of time remaining for the occurrence of any additional taxa that did not occur within the belt transects.

A.2.2.1 Percent benthic cover

Only the first two 25-m transect lines, previously laid out by the fish team, were surveyed for percent cover of benthic elements. Transect lines were previously labeled at 50-cm intervals. As the scientist swam along the transect lines, he inspected the benthic elements falling directly underneath each 50-cm mark on the transect line. Each such element was tallied and recorded under the following scheme: live coral, dead coral, carbonate pavement, coral rubble, sand, rock, macroalgae, turf algae, macroinvertebrate, and other. Live benthic elements including coral, algae, and invertebrates were identified to the lowest taxominic level possible. This data is used to provide the basis for quantitative estimates of live coral cover, as well as percent cover of the divrese benthic and substrate components.

A.2.2.2. Coral health and disease assessment

At each site, using the first two transect lines laid by the fish team, an area of 3–4 m (depending on bottom time) on each side of the transect lines (approx. 400–500 m^2) was surveyed to document incidence of coral bleaching and/or disease. Within this survey area, each diseased/afflicted coral colony was identified to the lowest taxonomic level possible, and the following information was recorded: (1) colony size; (2) type of affliction [bleaching, skeletal growth anomaly, white syndrome, tissue loss —other than white syndrome, trematodiasis, necrosis, other, and compromised health —pigmentation responses, algal overgrowth, predation, partial mortality); (3) area affected (percent live/dead); (4) severity of the affliction (mild, moderate, marked, severe, acute); and (5) photographic records and tissue samples were procured as needed. Tissue samples were catalogued and fixed in buffered zinc-formalin solution for further histopathological analyses. The disease data will be used to estimate disease incidence, prevalence; samples and photographs will be used to aid in further disease characterization.

A.2.2.3. Permanent USFWS coral transects
(*Jim Maragos*)

In July 1999, the U.S. Fish and Wildlife Service (USFWS) launched its program at Rose Atoll to establish permanently marked transects at all of its 10 National Wildlife

Refuges (NWR) in the remote tropical Pacific that protect coral reefs. Monitoring is more than a form of research—it is a fundamental management responsibility to implement the USFWS ”Wildlife First” mandate of the guiding legislation of the National Wildlife Refuge System. “Monitoring” is defined here as tracking changes in fish and wildlife populations at the same places over time. Coral reef benthic habitats are often characterized by high spatial heterogeneity over short distances. To maximize temporal variability relative to spatial variability, coral reef monitoring must be accomplished at the same sites over time; otherwise spatial heterogeneity may confuse any interpretation of temporal changes in coral reef populations.

In June 2000, the Service began installation of permanent transects, with four at Pearl and Hermes Atoll (PHR) in the Hawaiian Islands NWR, and three transects in the Midway Atoll NWR. With the assistance provided by NOAA ship cruises in the summers of 2001 and 2002, 30 additional permanent transects were established at all remaining islands in the Northwestern Hawaiian Islands except Kure which is under State of Hawaii jurisdiction. During October–November 2002, 5 additional transects were established at French Frigate Shoals (FFS), bringing the total number of transects in the NWHI up to 42 sites. Six earlier established transects at FFS were resurveyed during that same visit in late 2002, but none of these and the remaining transects have been resurveyed since 2000 to 2002.

Although some of the transects were established to achieve specific goals, such as to assess the impact of the grounded fishing vessel at Pearl and Hermes Reef (PHR) in 2000 and the initiation of construction of the Tern Island seawall in 2003, site selection for remaining transects was based upon covering a range of habitats on all sides of the complement of islands to depths of approximately 3–10 m. In some cases, transects were installed at greater depth, such as at 19 m off Nihoa to avoid hazardous swell and wave conditions in shallow water. In most cases, the transects were established in shallow water where reef and coral growth is generally highest and where self-contained underwater breathing apparatus (SCUBA) bottom time is more generous and needed because of the strenuous nature of transect installation, survey and resurvey. During most surveys, only a single person (Maragos) and a part-time dive buddy accomplished the installation and survey work. Ranya Henson, Yuko Stender, and Keoki Stender accomplished the initial monitoring surveys at Midway in 2002.

First, a 50-meter-long surveyor tape was laid along a depth contour that approximated the transect location. Then noncorroding stainless steel rods of 3/8-inch diameter, 1 foot in length, and grounded to a point at one end, were hammered into the reef at 5-meter intervals along the 50-m transect alignment at each site, and with care in maintaining the same established depth along the entire line. A total of 12 pins were established at each transect with 2 pins marking the beginning of each transect. Afterwards, marine epoxy was applied at the base of each pin using a double-barreled applicator gun with a mixing tip. The first and last pins defined the ends of each transect while all pins defined the precise alignment of each permanent transect line, although in some cases the interior pins were not spaced exactly at 5-m intervals. The earlier 2000

goals of establishing 100-m long transects with pins at 10-m intervals were abandoned because of the excessive time needed to relocate and survey the longer transects.

The reef habitat of all 42 transects were initially photographed using Nikon RS ™ film camera(s) with a 13-mm wide-angle lens mounted on a 1-m square photoquadrat frame. High resolution photos were taken at contiguous, 1-m intervals along the line, and the photographs later analyzed back in the office using Sigma Scan ™ software to accurately collect data on the genus (or species), number and size of each coral whose center fell within each photoquadrat. Although the goal was to photograph the entire 50 m^2 during a dive, film limitations, camera malfunctions, and time constraints prevented achievement of this goal at some sites. The photographs have all been scanned and stored at the offices of the USFWS and to serve as an archival database. Each of the photographed corals was later assigned to one of seven size classes based upon its long diameter: 1-5 cm, 6-10 cm, 11-20 cm, 21-40 cm, 41-80, 81-160 cm, and >160 cm, and following the methods of Mundy, 1995 and Maragos et al., 2004. These data were then used to estimate the size class distribution of each species or genus, generic diversity/transect, percent coral cover, mean diameter (cm), and frequency of corals (numbers/m^2). The photos also provide information on other macroinvertebrates, coral disease, predation, and bleaching.

All resurveys of transects in 2006 and beyond will involve in situ census of corals comparable to the procedures in place for the REA protocols for corals, but covering an area of 50 m^2 (1 m wide and 50 m long), the same area covered during the earlier phase in the NWHI and at other Pacific Remote Island NWRs. The same type of data will be generated in both cases, assigning each coral whose center falls within a half meter of the transect line to a genus and one of the seven size classes defined above. Using comparable methods for both REA and permanent transects allows all data within each atoll, reef, or island to be put to full use during analysis.

Northwestern Hawaiian Islands: coordinates for permanent transect sites 2000-2002

NOW-RAMP & CREI FIELD SITES: GPS COORDINATES through 2002

*= sites with no GPS coordinates & location estimated from chart
T= Townsend Cromwell (2000-1)
RD= Rapture/David Gulko Site (2000)
RJ= Rapture/Jim Maragos site (2000)
A= American Islander Site (2001)
S= *Swordman* grounding site monitoring transect (2000)
R= 2002 *Rapture* REA site
Rc= 2002 *Rapture* coral coring or coral collection site

P= permanent site
F= Fish & Wildlife Service Site
H= NMFS Hon Lab site
f= only fish surveyed at site
b= only benthos surveyed at site
CREWS=coral reef early warning system
Rm= 2002 *Rapture* permanent transect survey/resurvey
Rr= 2002 *Rapture* remote sensing site, includes DACOR

Grand total through April 2003: 2,234 m^2 sampling area for photo and in situ quadrat surveys.

French Frigate Shoals sum = 621m^2 17 sites

FIELD SITE #	DATE	TIME	LATITUDE	LONGITUDE	NOTES
FFS- P1	14-Jul-01	am	23.854917 N	166.323195 W	Shark Is. 50m permanent transect. PQ (25): 1-12, 25-37m.
FFS- P2	15-Jul-01	noon	23.644778 N	166.174500 W	Disappearing Is., 50m permanent transect. PQ (36): 1-19, 25-41m.
FFS- P3	16-Jul-01	am	23.769305 N	166.261583 W	La Perouse Pinnacle, permanent transect (50m). PQ (37): 1-16, 25-41m.
FFS- P4	16-Jul-01	pm	23.864717 N	166.211445 W	Serendipity Hollow, permanent transect (50m). PQ (35): 1-18m, 25-41m.
FFS- P5 (H6)	17-Jul-01	1400 hrs	23.880167 N	166.273195 W	N Tern ocean reef (Parrish 6), 50m permanent transect. PQ (37): 1-19, 25-43m.
			23.88017 N	166.27320 W	alternate coordinates for 5P in decimal minutes
FFS-F-10P	17-Jul-01	pm	23.86981 N	166.28786 W	N Tern dredged pit pinnacle, staked
FFS-F-7P	18-Jul-01	am	23.87131 N	166.28097 W	NE Tern staked corals- begin
"	"	"	23.87156 N	166.28267 W	NE Tern staked corals- end
FFS-F-8P	18-Jul-01	am	23.87139 N	166.28431 W	N Tern staked corals- begin
"	"	"	23.87092 N	166.28550 W	N Tern staked corals- end
FFS-F-6P	18-Jul-01	pm	23.86981 N	166.28961 W	NW Tern staked corals- begin
"	"	"	23.87014 N	166.28850 W	NW Tern staked corals- end

FFS-F-9P	29-Jul-01	noon	23.87144 N	166.28431 W	.
"	"	"	23.87150 N	166.28436 W	W Tern staked corals-end
FFS-CREWS/T16P	14-Sep-01	am	23.85713 N	166.27158 W	CREWS buoy site, PQ (37): 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21m (odd numbers) & 23m-50m. 37 total PQs.
FFS-Rrmc1 (P3)	11-Sep-02	1015 hrs	23.7794884 N	166.2615833 W	La Perouse Pinnacle, resurvey of permanent transect, also FFS-Rrmc1. PQ (18): 1-18m.
FFS-Rrcm4 (P2)	12-Sep-02	0934 hrs	23.644787143 N	166.17457996 W	core & remote sense site, Disappearing Is perm site resurvey, estab. 7/15/01. PQ (16): 1-16m.
FFS-Rrmc9 (P1a)	13-Sep-02	1540 hrs	23.854896016 N	166.323056147 W	Shark Island new 50m permanent transect, central south side. PQ (20): 32-51.
FFS-Rrm10 (16P)	4-Oct-02	1409 hrs	23.856691569 N	166.272223221 W	CREWS buoy site, 45m permanent transect resurvey. PQ (45): 1-45m.
FFS-Rrm11 (P4)	4-Oct-02	1718 hrs	23.863253080 N	166.211455610 W	Serendipity Hollow, permanent transect (50m), resurvey. PQ (49): 1-49m.
FFS- P11	30-Oct-02	1445 hrs	23.86438 N	166.21133 W	Serendipity Hollow #2, permanent transect (50m), new site, PQ (26): 14,16-17,22-23 & 30-50m
FFS-F-12P	31-Oct-02	0945 hrs	23.87161 N	166.28189 W	NE side of dredged channel NE of Tern, new permanent 50m transect, PQ (33): 1-17, 21-32, & 34-36
FFS-F-13P	31-Oct-02	1400 hrs	23.27155 N	166.28465 W	N side of dredged channel N of the center of Tern, new permanent 50m transect, PQ (36): 1-36m
FFS-F-14P	1-Nov-02	0900 hrs	23.86653 N	166.29054 W	W side of N-S dredged channel W, site SW of Tern, new perm. 50m transect. PQ (51):1-51m
FFS-Rrcm9 (P1a)	1-Nov-02	1400 hrs	23.854896016 N	166.323056147 W	resurvey of second Shark 50m permanent transect Rrcm9 established Sept 13, 2002. Fewer pins, PQ(52):1-52m
FFS- P3	2-Nov-02	0900 hrs	23.76931 N	166.26158 W	La Perouse Pinnacle, permanent transect (50m) resurvey, PQ (51): 1-51m, plus Preskitt photos
FFS-P5 (H6)	2-Nov-02	1530 hrs	23.87992 N	166.27341 W	resurvey of 50m permanent transect NE of Tern island on ocean reef, estab 7-17-01. 1-51m (51 PQ)
FFS-F-17P	28-Jul-01	daylight	23.86573 N	166.29020 W	25 photos from 8-10-01 to 8-26-01 of corals at ten stainless steel stakes off the NW to SW side of the entrance channel.
"	8/26/2001	daylight	23.86873 N	166.29052 W	
FFS-F-8P	31-Oct-02	1400 hrs	23.87139 N	166.28431 W	6 groups of tagged corals from 8P rephotographed during installation of 16P on Oct 31, 2002
FFS-11P	4-Sep-06	1100 hrs	23.863253080 N	166.21145561 W	resurvey of entire transect of 50m and replacement of several overgrown pins
FFS-16P	4-Sep-06	1500 hrs	23.856691569 N	166.272223221 W	resurvey of all portions of the 50m with corals (1-35 m with the remainder devoid of corals, added tall pins at both ends
FFS-2P	5-Sep-06	0900 hrs	23.644778 N	166.174500 W	Disappearing Island, 1-50m resurveyed, tall pins added at beginning, end and middle

Gardner Pinnacles sum = 20 m^2 1 site

FIELD SITE #	DATE	TIME	LATITUDE	LONGITUDE	
GAR-Rrm1	14-Sep-02	0909 hrs	24.998894912 N	167.99984037 W	W side near N end of larger (S) pinnacle in protected cove, new perm 50m trans. PQ (20): 38-57m.

Kure Atoll	sum = 0 m^2	0 sites			
FIELD SITE #	**DATE**	**TIME**	**LATITUDE**	**LONGITUDE**	
KUR-CREWS	1-Oct-01		28.4186 N	178.3446 W	Not yet monitored.
Laysan Island	sum = 76 m^2	2 sites			
FIELD SITE #	**DATE**	**TIME**	**LATITUDE**	**LONGITUDE**	
LAY-Rrm1	17-Sep-02	0940 hrs	25.774893379 N	171.743310303 W	new 50m perm. transect along N side of channel to W lagoon (N third). PQ (25): 27m to 51m.
LAY-Rrm5	18-Sep-02	1010 hrs	25.772361571 N	171.742308558 W	new 50m perm trans in S part of NW lagoon; laid offshore >100m to nearshore >50m SW. PQ (51): 1-51m.
Lisianski Island & Neva Sh.	sum = 153 m^2	3 sites			
FIELD SITE #	**DATE**	**TIME**	**LATITUDE**	**LONGITUDE**	
LIS-CREWS	Oct-01-01		25.9677 N	173.9161 W	Not yet montitored.
LIS-Rrm1	30-Sep-02	1120 hrs	26.057487856 N	173.971086930 W	fringing reef S of island, new permanent 50m transect. PQ: (51): 1-51m
LIS-Rrm6	1-Oct-02	1429 hrs	26.063605088 N	173.959039497 W	E nearshore island mound reef & new 50m permanent transect. PQ (51): 1-51m
LIS-Rrm9	2-Oct-02	1000 hrs	26.07737 N	173.96480 W	fringing reef N of island, new permanent 50m transect. PQ (51): 1-51m.
Maro Reef	sum = 96 m^2	3 sites			
FIELD SITE #	**DATE**	**TIME**	**LATITUDE**	**LONGITUDE**	
MAR-Rrcm1	15-Sep-02	0944 hrs	25.357855881 N	170.495292093 W	SE ocean-facing patch reef, samples, perm transect. PQ (37): 1-37m, progressively under-exposed but ok.
MAR-Rrm4	16-Sep-02	0949 hrs	25.46114794 N	170.68019849 W	NW linear reef tip, S side right at tip, permanent transect. PQ (24): 28-51m
MAR-CREWS/15P	21-Sep-01	noon	25.44652 N	170.63382 W	50m perm tran, W central lagoon, pins at10m, left to right, all PQ (35) with corals only:1-7, 10-13, 15-16,19-20, 23-24,
MAR-Rrm4	7-Sep-06	0945 hrs	25.46114794 N	170.68019849 W	successful resurvey and repair of entire permanent transect, including installation of 3 new pins at west end
MAR-CREWS/15P	7-Sep-06	1430 hrs	25.44652 N	170.63382 W	successful resurvey and repair of entire permanent transect, including pin replacement of 6 tall new pins at west end
Midway Atoll	sum = 681 m^2	11 sites			
FIELD SITE #	**DATE**	**TIME**	**LATITUDE**	**LONGITUDE**	
MID-1P	14-Aug-00		28.24445 N	177.323358 W	East Snorkel Reef, control transects C & D, no pins. 75m surveys

	MID-1P	14-Aug-00		28.24445 N	177.323317 W
	MID-2P	14-Aug-00		28.26028 N	177.34555 W
	MID-Rrm1-a (1P)	20-Sep-02	1550 hrs	28.244375813 N	177.323500935 W
	MID-Rrm1-c (1P)	20-Sep-02	1636 hrs	28.246306806 N	177.325265924 W
	MID-Rrm5 (2P)	21-Sep-02	1511 hrs	28.260763186 N	177.345135502 W
	MID-2P- cont.	21-Sep-02			
	MID-2Pc	21-Sep-02	1630 hrs		
	MID-Rrm7	23-Sep-02	1040 hrs	28.217802584 N	177.343979032 W
	MID-Rrm13	24-Sep-02	1030 hrs	28.277496739 N	177.366349743 W
	MID-Rrm14	24-Sep-02	1321 hrs	28.241900557 N	177.371587621 W
	MID-Rrm1-a (1P)	3-Dec-02	1400 hrs	28.244375813 N	177.323500935 W
	MID-F-16P	3-Dec-02	1230 hrs	28.27724 N	177.36854 W
	MID-F-17P	4-Dec-02	1000 hrs	28.23173 N	177.31812 W
	MID-F-18P	4-Dec-02	1300 hrs	28.26351 N	177.33798 W
	MID-F-19P	5-Dec-02	1000 hrs	28.19357 N	177.40169 W
	MID-F-20P	6-Dec-02	1000 hrs	28.27144 N	177.38597 W

East Snorkel Reef, control transects A & B, no pins. 75m surveys

Platform Reef with 3 separate 25m transects (75m). Now 1st two combined as "2P" from 0-60m, & 3rd as "2Pc" @ 1-26m.

outer 25m perm trans resurvey (1Pa), Yuko & Ranya, E reef, no quadrat frame. PQ (18): 8m-25m.

inner 25m permanent transect resurvey (1Pc), Yuko & Ranya, E reef: PQ (27): 1-11m, 12-28m.

NNE backreef at Platforms (2P), resurveying Yuko & Ranya perm trans, PQ (40): 1-32m for 1st trans & 33-40m for 2nd (beginning pin for 2nd @ 33m).

Platform Reef with 3rd transect further in the lagoon in deeper water. PQ (14): 13-26m

E lagoon, CREWS buoy, new 30m perm trans.No quadrat frame. PQ (19): 8-26m.

same as Rr10, but 25m to N, 53m permanent transect, N shallow lagoon, heavily bleached coral area. PQ (52): 1-52m.

SW lagoon patch reef, 60m permanent transect. PQ (38): 1-38m.

relocated and resurveyed all 25m photoquadrats at East Snorkel Reef (1Pa), PQ (26); 1-26m

Reef Hotel, new 50m perm transect, S to N, 50m W of the pilings for hotel, just W of sand area/channel, PQ(50): 1-50m

E back reef, (no epoxy used on stakes), (also R18B), new 50m perm transect, PQ (51): 31-51m

NE back reef (also R16B), new 25m perm transect, no quadrat frame. PQ (26): 1-26m

SW lagoon corner, new 50m perm transect, PQ (43): 1-9m, 12-34m, 36-46m

NW lagoon back reef (also R20B), new 50m perm transect, PQ (52): 1-52m

Necker Island sum = 57 m^2 1 site

FIELD SITE #	DATE	TIME	LATITUDE	LONGITUDE	
NEC-Rrm1	10-Sep-02	1000 hrs	23.57537 N	164.70515 W	
NEC-Rrm1	3-Sep-06	1330 hrs	23.57537 N	164.70515 W	

permanent transect, S side, PQ (57): 1-57m

resurveyed permanent transect, (1-50 m) and repaired end of transect with two 3-foot high pins; also referred to as NEC-1P

Nihoa Island sum = 57 m^2 2 sites

FIELD SITE #	DATE	TIME	LATITUDE	LONGITUDE	
NIH-Rm1	9-Sep-02	1425 hrs	23.06233 N	161.92965 N	
NIH-Rrm2	6-Oct-02	0847 hrs	23.060156463 N	161.929709866 W	

permanent transect W side, first 28m blurred, 29-36m underexposed, 36m-51m ok, PQ (43). 8 PQ without the line.

50m permanent transect W side near SW corner, PQ (14): 1m, 35-47m.

Pearl & Hermes Atoll sum = 473 m^2 8 sites

FIELD SITE #	DATE	TIME	LATITUDE	LONGITUDE	
P&H-S-1P [PH4]	13-Jun-00	afternoon	27.8319118 N	175.7511825 W	SE ocean reef, 100m perm. transect, S of grounding. PQ (74): 1-18m, 25-43m, 51-68m, 75-93m.
P&H-S-2P [PH3]	13-Jun-00	morning	27.8335194 N	175.7510431 W	SE ocean reef, N of grounding. 100m perm transect. PQ (74): 1-18m, 25-43m, 51-68m, 75-93m.
P&H-S-3P [PH6]	14-Jun-00	morning	27.8337095 N	175.7538171 W	SE backreef, S of grounding. 100m perm. transect, frame unattached to quadrat. PQ (72):1-18m, 25-42m, 51-68m, 75-92m.
P&H-S-4P [PH7]	14-Jun-00	afternoon	27.8345869 N	175.7535021 W	SE backreef, N of grounding. 100m perm trans, PQ (36) mostly slides & some prints:1m, 4m, 7-17m, 51-62m, 75-85m.
P&H-CREWS (5P)			27.8541 N	175.8159 W	Not yet monitored
P&H-Rrm1 (6P)	19-Sep-02	1328 hrs	27.817100632 N	175.833683718 W	new permanent 50m transect on shallow mound in S lagoon, 1st roll under-exposed, PQ (46): 1-9m (under-exp), 14-50m.
P&H-Rrm3 (7P)	27-Sep-02	1226 hrs	27.864787873 N	175.792791273 W	central lagoon, new 50m permanent transect, finger coral gardens. PQ (55): 1-37m, 40m- 57m.
P&H-Rrm9 (9P)	28-Sep-02	1003 hrs	27.794535849 N	175.859424599 W	S pass new 50m permanent transect. PQ (54): 1m to 54m
P&H-Rrm12 (12P)	29-Sep-02	0950 hrs	27.763630027 N	175.973193021 W	W fore reef, spurs-and-grooves, new 50m permanent transect. PQ (62): 1m to 62m.

last revised 9-3-06

Table 2.2.3.1 Description and location of USFWS permanent coral transects.

A.2.3 Fish

The Rapid Ecological Assessment (REA) Fish Team conducted three types of surveys at REA sites: Belt Transects (BLT), Stationary Point Counts (SPC), and Roving Diver REAs. BLTs were performed along three consecutive 25-m lines set along a single depth contour. As each line was set, two observers swam about 5 m apart along either side of the line, identifying to the lowest possible taxon, counting, and recording size classes for all fishes >20 cm total length (TL) within an area 4 m wide and 4 m high. At the end of each 25-m line, the divers turned around and returned along their respective sides of the line identifying, counting and recording size classes of all fishes <20 cm TL within 2 m of their side of the line and 4 m off the bottom. The third fish team diver simultaneously conducted four SPCs at each REA site, generally ~15 m from the transect line. SPCs consist of the diver identifying, counting, and recording the size classes for all fishes >25 cm total length observed in a cylindrical volume 10 m in radius during a 5-minute period. Following and opportunistically during the BLT and SPC surveys, all three fish team divers recorded the presence of all fish species seen outside the transect area and outside the SPC counts. The fish REA team's species presence records are combined with fish species observed by other divers (benthic team, tow team, or mooring team) to develop an island-wide record of all fishes observed. No collection efforts were made by the fish REA team during HI0611.

A.3. Towed-diver Survey Methods
(Brian Zgliczynski, Jake Asher, Edmund Coccagna,and Stephane Charette)

The fish towboard, outfitted with a forward-looking digital video camera, recorded fish distribution and habitat complexity. The diver on this board recorded fishes larger than 50 cm total length along a 10-m swath during a 50-minute survey. The downward looking benthic towboard, affixed with a high-resolution digital camera with dual strobes, photographed the benthic substrate every 15 seconds. The diver on this board calculated substrate percentage every 5 minutes, recorded habitat type and complexity, and tallied the quantity of macroinvertebrates. Each towboard was equipped with an SBE-39 which recorded temperature and depth every 5 seconds along the tow. A Garmin GPS76 Map Global Positioning System (GPS) was used to record position at 5-second intervals along each tow track to georeference the collected data.

Towed-diver surveys were conducted across multiple habitats including the forereef, backreef, lagoon, and insular shelf.

A.4 Shark Recievers
(*Carl Meyer and Yannis Papastamatiou*)

Recovery & redeployment of existing receivers

We recovered, downloaded, and redeployed underwater acoustic receivers currently deployed at Northwestern Hawaiian Islands Marine National Monument (NWHIMNM) locations described in Table A.5.1. We removed receivers from their

moorings and returned them to the ship where they were downloaded and equipped with new batteries, before redeployment at their original sites.

Deployment of new underwater receivers

We created receiver moorings at the sites described in Table A.5.2. Moorings consisted of sand screws in areas of soft sediment and chain around uncolonized substrate in hard bottom areas. The receivers were anchored to the moorings and suspended 1–4 m above the ocean floor. The receivers will identify and record the presence of any transmitter-equipped predators within range (up to 500 m). The transmitter number, time of arrival and departure, and the date will be recorded and stored until the data are downloaded from the receivers to a computer. The receivers have a battery life of approximately 15 months and will be serviced at 6- to 12-month intervals.

Table A.5.1. Locations of underwater acoustic receivers currently deployed in the NWHIMNM.

Atoll	Location	Latitude	Longitude	Depth (ft)
Nihoa	West Side	23.061	-161.931	55
FFS	Rapture Reef	23.635	-166.186	85
FFS	La Perouse	23.769	-166.262	30
FFS	East Island	23.787	-166.207	10
FFS	Tern Island	23.867	-166.288	15
FFS	Trig Island	23.869	-166.242	10
FFS	Trig Island	23.869	-166.242	10
Maro	Shark Point	25.461	-170.682	50
Maro	North Tip	25.458	-170.671	55
P&H	SW Corner	27.753	-175.948	50
P&H	SE Channel	27.787	-175.836	30
P&H	Main Channel	27.791	-175.863	35
P&H	NW Side	27.911	-175.909	75
Midway	Frigate Point	28.191	-177.395	30
Midway	Fish Hole	28.197	-177.363	40
Midway	North Flats	28.277	-177.372	8
Kure	SE Channel	28.382	-178.309	60
Kure	West Channel	28.404	-178.375	40
Kure	North Flats	28.452	-178.315	12

Table A.5.2. Locations of new underwater receivers in the NWHIMNM .

Atoll	Location	Latitude	Longitude	Depth (ft)
Gardner Pin.	W. of Main Pinnacle	24.998	-167.999	47
Laysan	S. Laysan Island	25.755	-171.716	60
Laysan	W. Laysan Island	25.774	-171.742	30
Lisianski	South Lisianski	25.943	-173.885	45
Lisianski	E. Lisianski Island	26.067	-173.960	10

Appendix B: Necker Island

B.1. Oceanography and Water Quality

Oceanography and Water Quality

One oceanographic data platform (ODP), which measures directional currents, wave heights, temperature and salinity, was recovered from the southwest side of Necker. The ODP anchor was also removed. One subsurface temperature recorder (STR) was recovered from the south side of the island. The sea surface temperature (SST) buoy previously deployed during HI0501 was no longer present as the line appeared to have been cut or likely chaffed through. The SST anchor and line were recovered and removed from the site. No instruments were replaced as the Coral Reef Ecosystem Division (CRED) will not be returning to Necker Island on future Reef Assessment Monitoring Program (RAMP) cruises.

Temperature data obtained from the ODP in 25 m of water from April 2005 to September 2006 shows primarily seasonal variations (Fig. B.1.1). In each year, June through September are observed to be the warmest months, while the coolest temperatures occurred from February to May in 2006. A sharp rise in temperature (> 3 °C) is observed in May 2005 and again in late May 2006. Further data analysis and additional information are needed to better understand what caused this rapid increase in temperature.

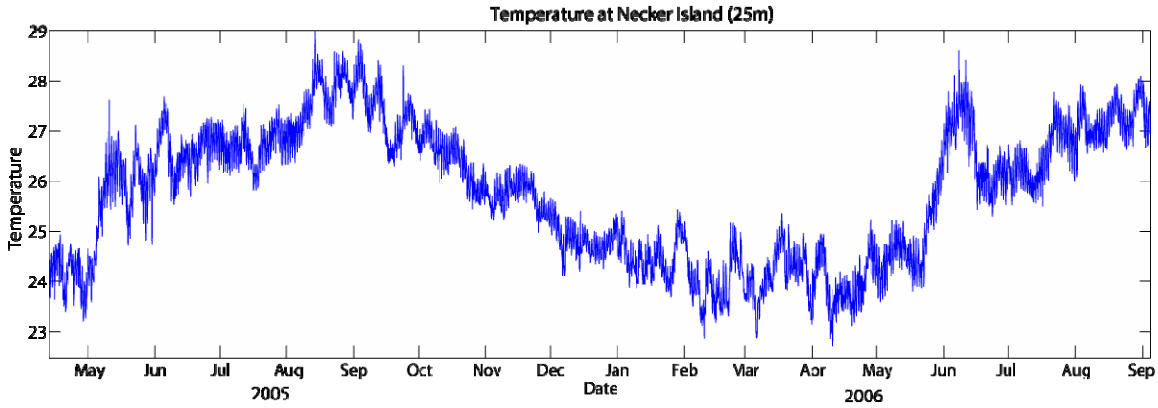

Figure B.1.1: Temperature data obtained from the southwest side of Necker Island at 25 m depth.

B.2. Rapid Ecological Assessment (REA) Site Descriptions

NEC-2
September 3, 2006

West, ocean fringing reef; low-relief, spur and groove reef with shallow sand channels. Depth range: 13.5–18 m. First transect compass heading 0^{o}, second transect compass heading 30^{o}. Turf algae and a species of *Halimeda* were ubiquitous.

Cyanophytes, crustose coralline red algae, *Ventricaria ventricosa*, a species of *Dictyota*, and *Gibsmithia hawaiiensis* were also found inside sampled photoquadrats. *Caulerpa macrophysa*, *Tolypiocladia glomerulata*, and *Amansia glomerata* were collected during the random swim. Moderately high live coral cover (30.4%); high coral cover along second transect with large, encrusting *P. lobata* (highly fissioned) and *P. meandrina.* Thirteen anthozoan species (twelve scleractinian and *Palythoa*) enumerated within 50 m^2 belt. One additional scleractinian species observed outside belt transects, as well as one colony *Acropora cytherea* reported by Vargas Angel.

Coral disease and health assessment: Many cases (19) of possible trematodiasis with pigmentation response on *P. lobata* + *P. lutea*, 1 case of bleaching on *M. capitata*, and 3 cases of compromised health (pallor) on *Pocillopora eydouxi* (2) and *P. lobata* (1). Fish surveys were dominated by surgeonfish, with lots of *olivaceus*. Other fishes of note were *Sphyraena barracuda*, a couple grey reefs, a few uku, and an eagle ray. There were a few parrotfish and a school of opelu that swam by. Again, this site did not have very good shelter for fish, and overall abundances were low.

NEC-4
September 3, 2006

West-southwest, ocean fringing reef, with low carbonate pavement relief. Depth range: 11–12.5 m. Transect depth range 38-40 feet, compass heading 270^o. Top of ledge; sand-coated pavement, low topographical relief. Flat reef area dominated by algal turf and numerous, small individuals of a species of *Halimeda*. Cyanophytes and crustose coralline red algae also commonly occurred, but in much lower abundance than *Halimeda*. Non-geniculate branched calcified red algae and a species of *Laurencia* were also found within surveyed photoquadrats. *Halichrysis coalescens* and *Caulerpa macrophysa* were collected during the random swim at the end of the dive. Numerous small, encrusting *P. lobata* colonies and small colonies *P. meandrina*. Ten anthozoan species (nine scleractinian and *Palythoa*) enumerated within 50 m^2 belt. Four additional anthozoan species (three scleractinian and *Zoanthus*) observed outside belt transects. One colony *Acropora cytherea* seen (~20 cm diameter), partially preyed upon by *Acanthaster*. Relatively low coral (9.8%); dominated by *Porites* sp.

Coral disease and health assessment: Two cases of possible trematodiasis with pigmentation response on *P. lobata* and three cases of compromised health (partial mortality most probably as a result of predation) on *P. lobata* and *P. lutea*. Overall, this site was characterized by low abundance and diversity of fishes. It was surgeonfish dominated, with lots of *Acanthurus olivaceus.* A couple of uku, white tip sharks, and a grey reef where spotted by the fish team. There was not too much shelter for fish.

B.3. Benthic environment

B.3.1. Algae

Quantitative algal surveys were conducted at two sites located towards the west end at Necker Island (NEC-2, NEC-4). Both sites appear to be scoured by high wave energy, and in both areas turf algae dominated the substrate. Numerous, small individuals of *Halimeda velasquezii* were extremely prevalent at NEC-4, whereas NEC-2 contained fewer, larger individuals (Table B.3.1.1). Although still awaiting microscopic confirmation, 10 species of macroalgae were collected along survey lines (Table B.3.1.2): 3 species of green algae, 6 species of red algae, and 1 species of brown algae. Microscopic examination of epiphytes will increase the number of species collected substantially.

Table B.3.1.1: Algal genera or functional groups recorded in photoquadrats at Necker Island. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	NEC-4	NEC-2
GREEN ALGAE		
Caulerpa	0.0	0.0
	0.0	**0.0**
Halimeda	*100.0*	*100.0*
	2.0	**2.0**
Ventricaria	0.0	*8.3*
	0.0	**5.0**
RED ALGAE		
Amansia	*0.0*	*0.0*
	0.0	**0.0**
Non-geniculate calcified branched red algae	*16.7*	*0.0*
	3.5	**0.0**
crustose coralline algae	*100.0*	*75.0*
	3.6	**12.8**
Gibsmithia	*0.0*	*8.3*
	0.0	**5.0**
Halichrysis	*0.0*	*0.0*
	0.0	**0.0**
Laurencia	*25.0*	*0.0*
	3.7	**0.0**
Tolypiocladia	*0.0*	*0.0*
	0.0	**0.0**
BROWN ALGAE		
Dictyota	*0.0*	*50.0*
	0.0	**3.3**

	NEC-4	NEC-2
FUNCTIONAL GROUPS		
turf algae	*100.0*	*100.0*
	1.0	**1.0**
Cyanophytes	*58.3*	*33.3*
	3.6	**3.8**

Table B.3.1.2: Putative algal species found at Necker Island. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis.

List of putative macroalgal species collected.
(one sample per site)

	NEC-4	NEC-2
GREEN ALGAE		
Caulerpa macrophysa	X	X
Halimeda velasquezii	X	X
Ventricaria ventricosa		X
RED ALGAE		
Amansia glomerata		X
Non-geniculate calcified branched red algae	X	
Gibsmithia hawaiiensis		X
Halichrysis coalescens	X	
Laurencia sp.	X	
Tolypiocladia glomerulata		X
BROWN ALGAE		
Dictyota spp.		X

B.3.2. Corals

Coral Rapid Ecological Assessment (REA) surveys were conducted at two sites, NEC-4 along the southwest exposure and NEC-2 along the northwest exposure. The most recent surveys by CRED at both sites were conducted on July 14, 2003; neither site was surveyed by CRED in 2004, when inclement sea conditions did not allow launching the dive boats. However, both sites were surveyed by Dr. Greta Aeby and Dr. Evelyn Cox during the NWHI Ecosystem Reserve cruise on October 4, 2005. At both sites this year, permanent transect markers were installed along the first two transects by members of the REA fish team with the intention of reducing error because of spatial imprecision on future surveys. Global Positioning System (GPS) site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded after descending in order to facilitate relocating the markers on future surveys.

B.3.2.1 Coral populations

A total of 689 colonies belonging to 13 anthozoan taxa were enumerated within belt transects enclosing 100 m^2 benthic substrate (Table B.3.2.1.1). The most frequently occurring taxa were *Pocillopora meandrina* and *Porites lobata*. Four additional taxa not seen within belt transects were observed within the larger survey area surrounding the transect belts (*Acropora cytherea, Leptastrea bewickensis, Pavona maldivensis,* and *Zoanthus pacifica*).

Table B.3.2.1.1 Number of anthozoans enumerated within belt transects at Necker during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

	Necker 2006	
Taxon	# of colonies	Percent of total
Acropora cytherea	0	0.0
Acropora valida	0	0.0
Acropora humilis	0	0.0
Montipora capitata	19	2.8
Montipora patula	17	2.5
Montipora verilli	0	0.0
Montipora flabellata	0	0.0
Montipora turgescens	0	0.0
Montipora incrassata	2	0.3
Pavona duerdeni	13	1.9
Pavona varians	1	0.1
Cyphastrea ocellina	0	0.0
Leptastrea purpurea	4	0.6
Fungia scutaria	0	0.0
Pocillopora damicornis	0	0.0
Pocillopora eydouxi	0	0.0
Pocillopora ligulata	5	0.7
Pocillopora meandrina	199	**28.9**
Porites brighami	4	0.6
Porites compressa	26	3.8
Porites evermanni	14	2.0
Porites lobata	381	**55.3**
Palythoa sp.	4	0.6
Zoanthus pacifica	0	0.0
Total # colonies	689	100.0
Area surveyed, m^2	100	

Size class distributions of all corals enumerated within belt transects are shown in Figure B.3.2.1.1. Of the 689 colonies whose maximum diameter was visually estimated, 40.1% had a maximum diameter <10 cm, and only 3.2% had a maximum diameter >40

cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003 and 2005 surveys.

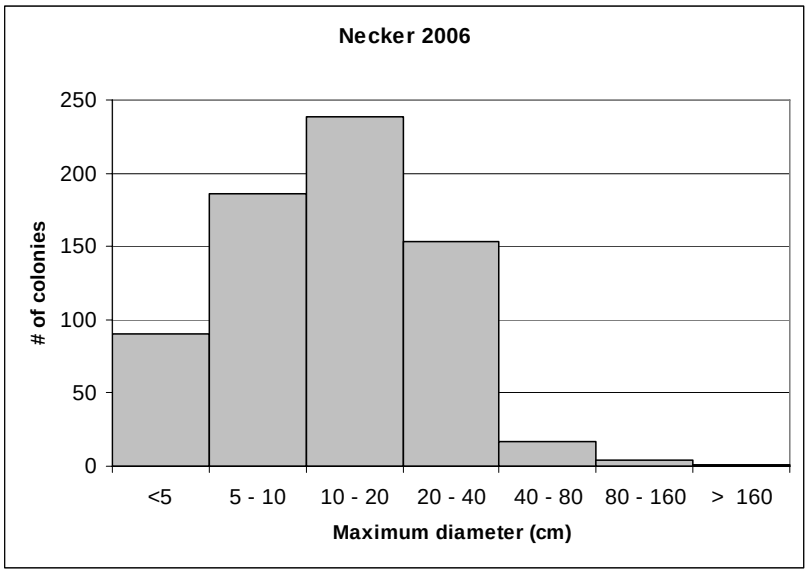

Figure B.3.2.1.1 Size class distributions of all corals

B.3.2.2. Percent benthic cover

Percent benthic cover surveys were conducted in congruency with coral population surveys, at sites NEC-4 and NEC-2. Mean coral cover at Necker was >22% and *Porites lobata* (16.2%) and *Pocillopora meandrina* (2.5%) were the two salient scleractinian taxa. Other coral taxa enumerated along the point intercept transects included: *Porites evermanni/lutea*, *Pocillopora eydouxi*, and *Montipora capitata* . Turf algae colonizing the carbonate pavement, as well as *Halimeda* also accounted for a substantial portion of the biological benthos (Table B.3.2.2.1).

Table 3.2.2.1 Percent cover of the most salient benthic elements at Necker Island, during the 2006 REA activities.

Species	Total	% Cover
Halimeda	25	12.3
Montipora capitata	1	0.5
Pavement/cca	11	5.4
Pavement/cyano	3	1.5
Pavement/turf	105	51.5
Pocillopora eydouxi	3	1.5
Pocillopora meandrina	5	2.5
Porites lobata	33	16.2
Porites evermanni/lutea	3	1.5
Sand	15	7.4
Grand Total	204	

B.3.2.3 Coral disease

In 2006, the coral disease REA surveys detected three main types of coral diseases at NEC-2 and NEC-4, including bleaching, tissue loss, and trematodiasis. Tissue loss and trematodiasis were present in both *Porties lobata* and *Porties evermanni/lutea*. In addition, one case of coralline orange lethal disease was noted at NEC-2. Finally, several cases of a compromised health state, involving pigmentation responses and discoloration were observed colonies of *Porites* and *Pocillopora*, respectively. A tissue sample of pigmentation responses on *Porites lobata* was collected for further histopathological analyses (Table 3.2.2.1.).

Table 3.2.2.1 *Porites lobata* sample of pigmentation responses.

Disease/Syndrome	Species	No. Cases
Bleaching	*Montipora capitata*	1
Tissue loss	*Porites lobata*	2
	Porites evermanni/lutea	1
Trematodiasis	*Porties evermanni/lutea*	1
	Porites lobata	8
Coralline lethal orange disease	Crustose coralline algae	1
Compromised health state -Pigmentation response	*Porites lobata*	3
	Porites evermanni/lutea	9
Compromised health state -Discoloration	*Pocillopora eydouxi*	2
	Porites lobata	1
Grand Total		28

Figure 3.2.2.1 shows the cumulative number of cases of disease and compromised health state conditions enumerated along the survey areas at Necker Island during the 2006 Reef Assessment and Monitoring Program (RAMP) cruise. In addition, Figure 3.2.3.2 illustrates an itemized breakdown of the taxa exhibiting disease and compromised health. At a future date, these data will be related to coral colony densities and coral cover in order to estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

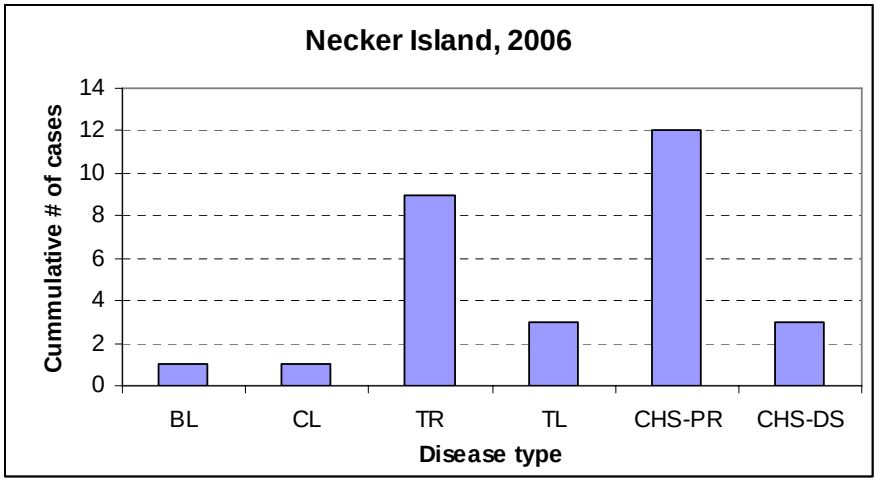

Figure 3.2.2.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at Necker Island during the 2006 RAMP cruise.

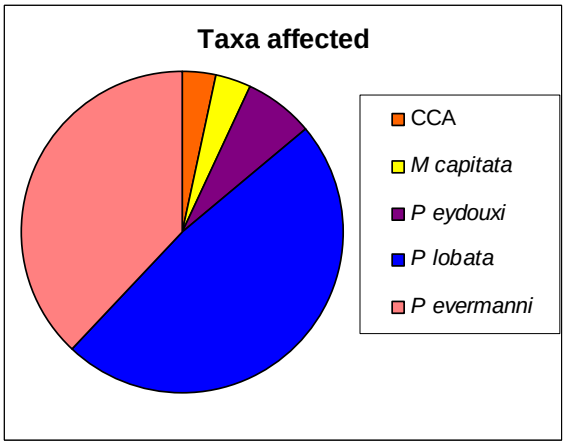

Figure 3.2.2.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at Necker Island, 2006.

B.3.2.4 USFWS permanent coral transects

Permanently marked transect NEC-1P is located on the southwest side of Necker Island and is the only permanent transect established there to date. The transect was successfully found and resurveyed on September 3, 2006 for the first time since it was established on September 10, 2002. The initial survey covered 57 m^2 while the resurvey covered 50 m^2. All stakes were relocated except the last, and Yannis Papastamatiou and Carl Meyer kindly assisted in the installation new tall (3 ft) stakes to repair and mark the end of the transect.

All coral population parameters increased during the 4-year period between the two surveys. Mean diameter increased from 8.4 cm to 10.6 cm. Coral frequencies increased from 9.1 to 18.4 corals per m^2, and generic diversity increased from 2 to 5 genera. All four of the smaller size classes for total corals increased substantially during

the 4-year period although there were only a few corals represented at the higher size classes for each survey period (see Fig. B.3.2.4.1 below). Overall, all smaller size classes increased and the larger stayed the same. Severe exposure to waves from any direction and the large winter swell from the northwest may prevent development of large, high profile corals. The lobe coral *Porites lobata* followed by the rose/cauliflower coral *Pocillopora meandrina* continue to dominate the coral fauna, although the zoanthid soft coral *Palythoa tuberculosa* has emerged as a common coral on the transect in 2006, even though absent in 2002. The number of *Porites* corals doubled for the all four smaller size classes while *Pocillopora* also increased dramatically in all size classes. Although calculations are not yet complete, live coral cover in 2006 will likely be double the value of 5.17 % reported in 2002. The total number of corals in 2006 within the 50-m transect was 924 compared to 517 corals on the 57-m transect in 2002. Despite the exposed and scoured environment at the site, corals have increased dramatically at NEC-1P over the 4- year period.

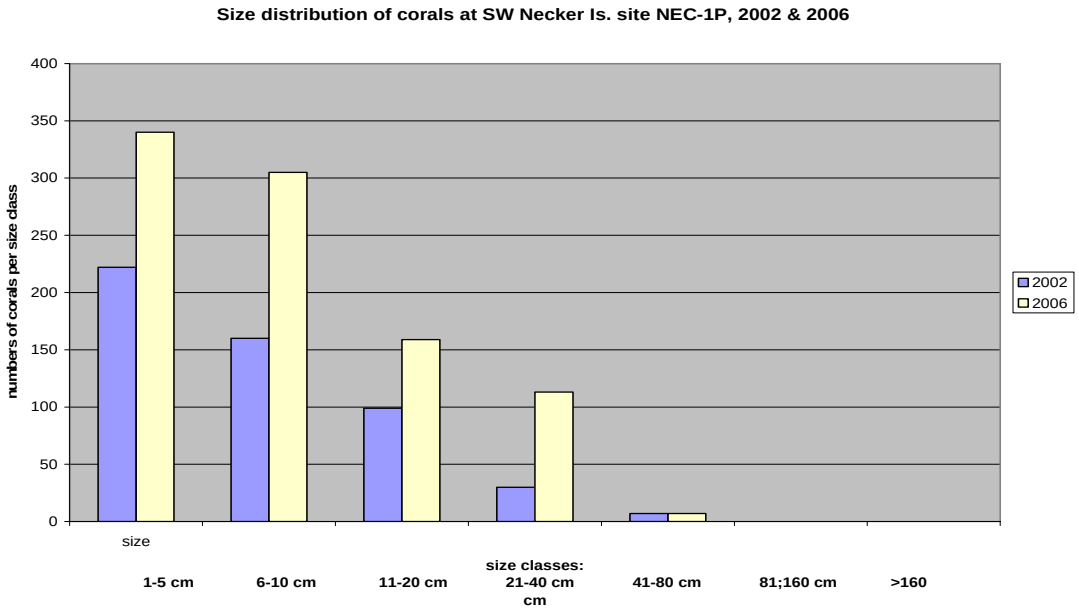

Figure B.3.2.4.1 Size distribution of coral at Necker Island.

B.3.3 Towed-diver Benthic Surveys

During the four towed-diver habitat surveys conducted at Necker Island, medium-low complexity pavement was recorded as the dominant habitat, with sparse patches of spur and groove reef located along the northwestern section of the island. We observed the reef habitat to be covered with a relatively even distribution of 19.2% live coral, 38.6% macroalgae, and 2.6% coralline algae. Species of *Halimeda* were noted during every time segment recorded over the course of all four tows. Notable increases in species of sea urchins were documented in the southwest and northeast regions of the island. No crown-of-thorns starfish were observed.

B.4 Fish

B.4.1 REA Fish Surveys

Stationary Point Count (SPC) data

A total of 192 fish of 23 species were seen in SPC surveys at the two Necker sites, and 182 of the fishes were 30 cm or smaller. *Naso brevirostris* was by far the most numerically dominant species (110 individuals counted), followed by *Acanthurus olivaceous* and *Bodianus bilunulatus*.

Belt Transact data

A total of 590 fish of 40 species were counted at the two sites on BLT transects. The most numerically abundant species were *Chromis vanderbilti*, *Naso brevirostris*, and *Acanthurus olivaceous*. The size frequencies of these fishes are depicted in Figure B.4.1.1.

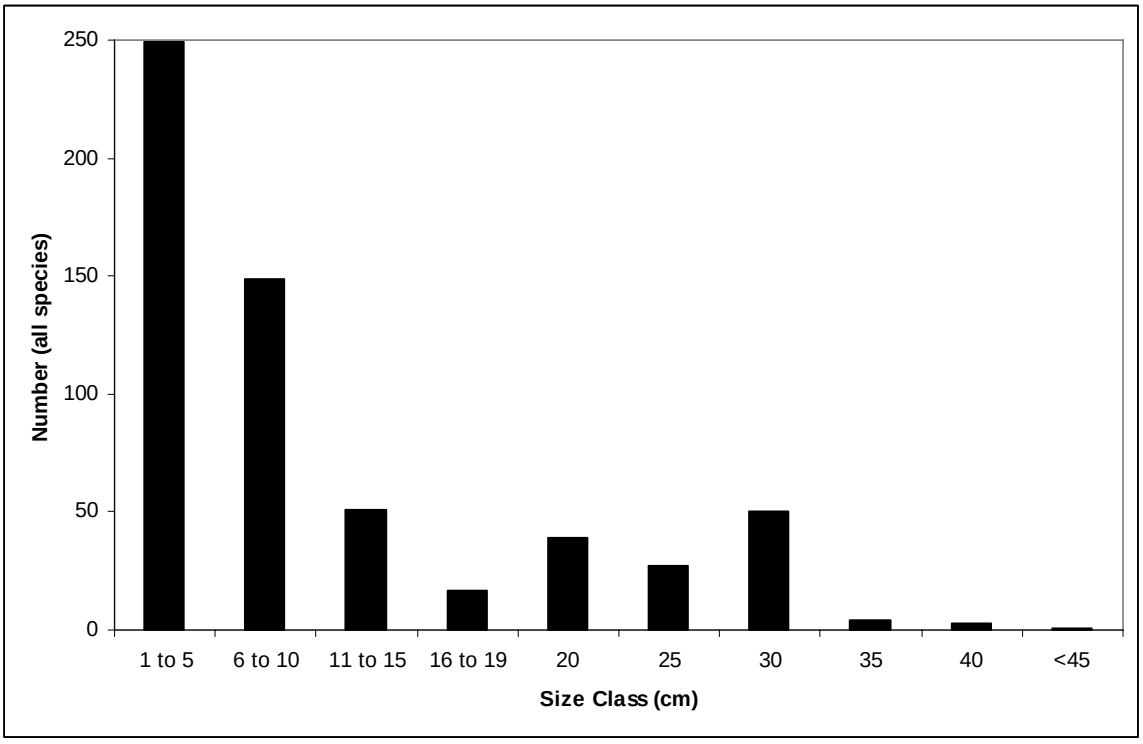

Figure B.4.1.1. Size frequencies of fish at Necker Island.

Only one fish larger than 45 cm was seen on BLT transects.

Overall observations:

Seventy-four total species of fish were observed on REAs by all divers, including tow team divers. Both sites we surveyed (NEC-4 and NEC-2) were characterized by low

diversity and abundance of fishes. Surgeonfish were dominant, and a few large predators were seen (see site summaries for details of notable fish sightings).

B.4.2 Towed-diver Fish Surveys

The tow team conducted four towed-diver habitat and fish surveys at Necker Island, surveying approximately 7.48 km total. A total of 61 fishes over 50 cm TL were observed.

Fish Observations

The mean numeric density at Necker Island was 0.7 fish per hectare (± 95 % CL), as seen in Figure 4.2.1. The biomass was approximately 0.12 tons per hectare (mean ± 95 % CL) (Fig. 4.2.2).

At the family level, Carangids made up the majority of observations with 23 sightings. The giant trevally (*Caranx ignoblis*) accounted for 20 of those sightings, the bluefin trevally (*Caranx melampygus*) accounting for the remaining 3. The Lutjanids were the second most observed family with 10 sightings, all being the grey snapper (*Aprion virescens*).

The giant trevally (*Caranx ignoblis*) was the most common species seen (20 observations) followed by the grey snapper (*Aprion virescens*) (10). Other notable observations included seven white-tip reef sharks (*Triaenodon obseus*), two grey reef sharks (*Carcharhinus amblyrhynchos*), and nine bigeye emperors (*Monotaxis grandoculis*).

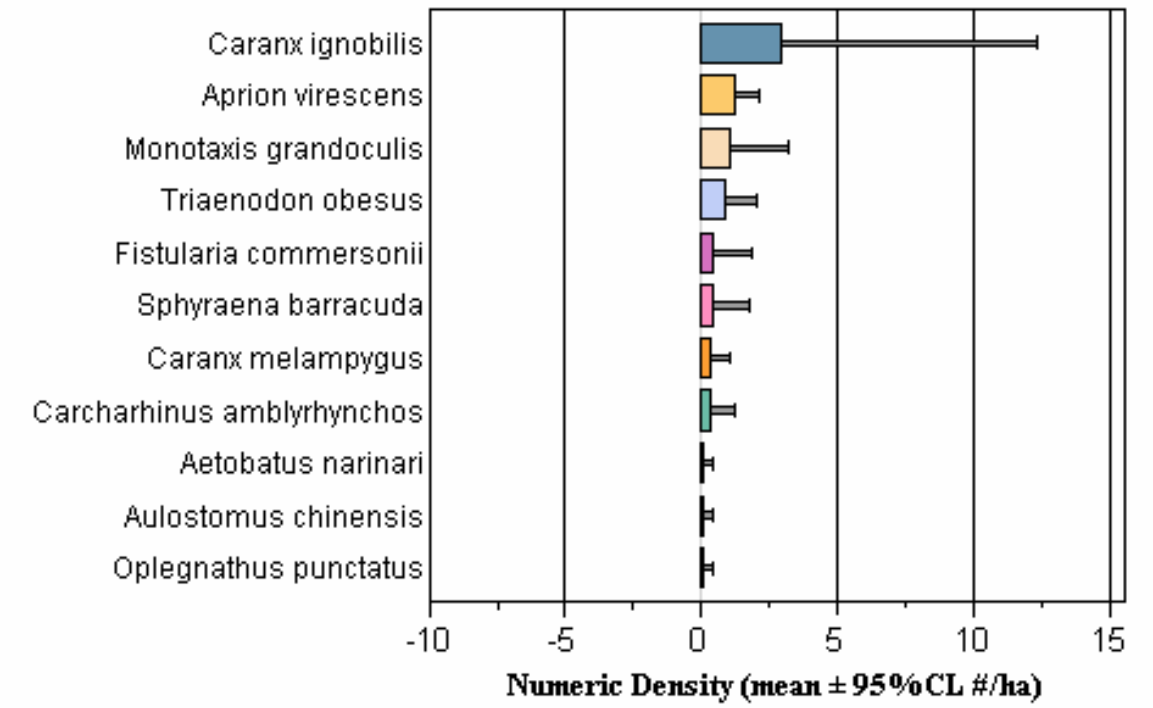

Figure B.4.2.1 The numeric density (number of fishes ha^{-1}) of the 11 most commnly observed fishes at Necker Island during the survey period.

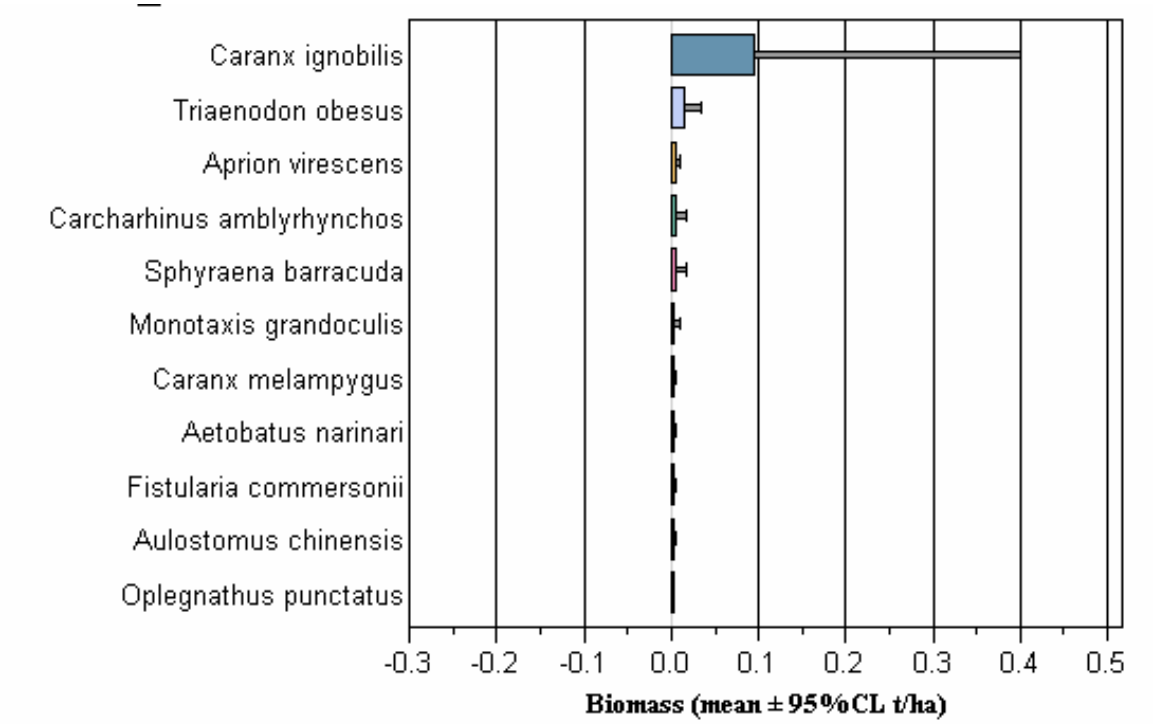

Figure B.4.2.2. The total grand mean biomass (t ha^{-1}) of the 11 most commonly observed fishes at Necker Ilsnad during the survey period.

B.4.3 Shark receivers

We returned to the location of our Necker receiver and discovered that it was missing. We did not replace this unit because of the risk of losing additional receivers in the high energy environment close to the island.

B.5 Maps

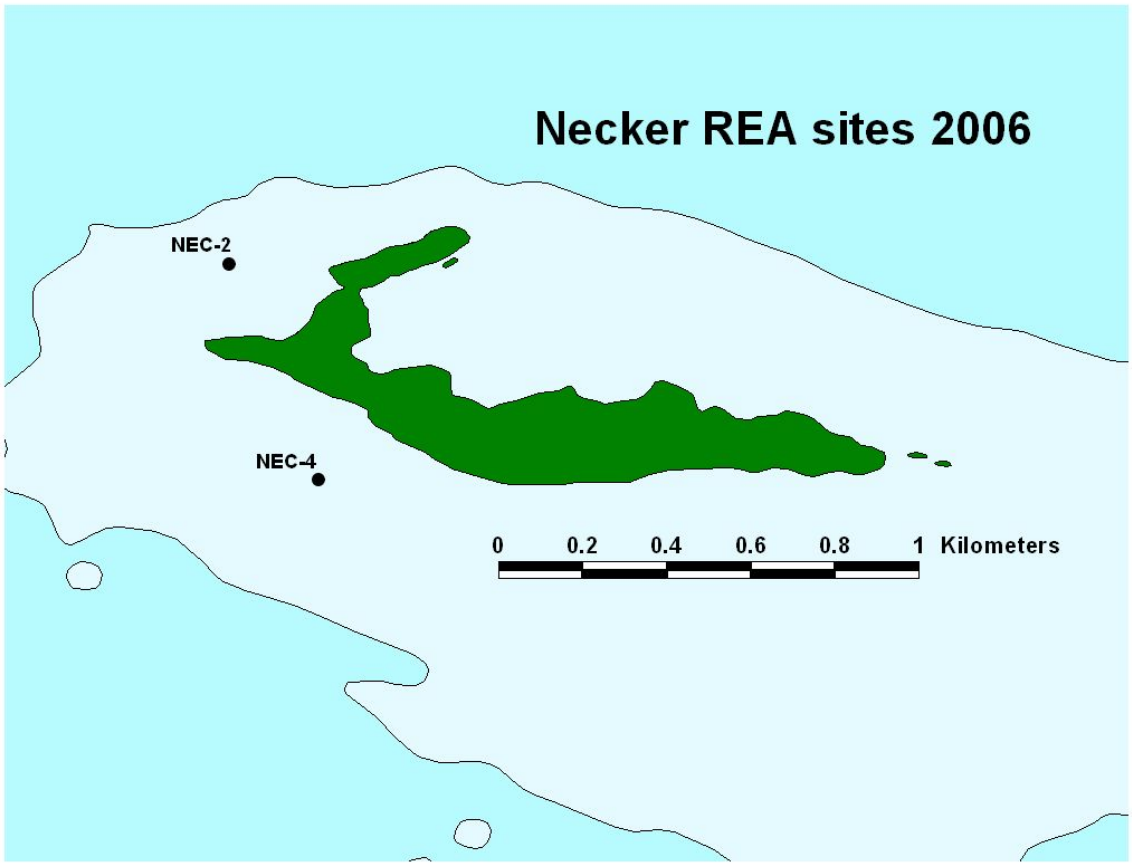

Figure B.5.1. Map showing location of 2006 Rapid Ecological Monitoring (REA) sites at Necker Island.

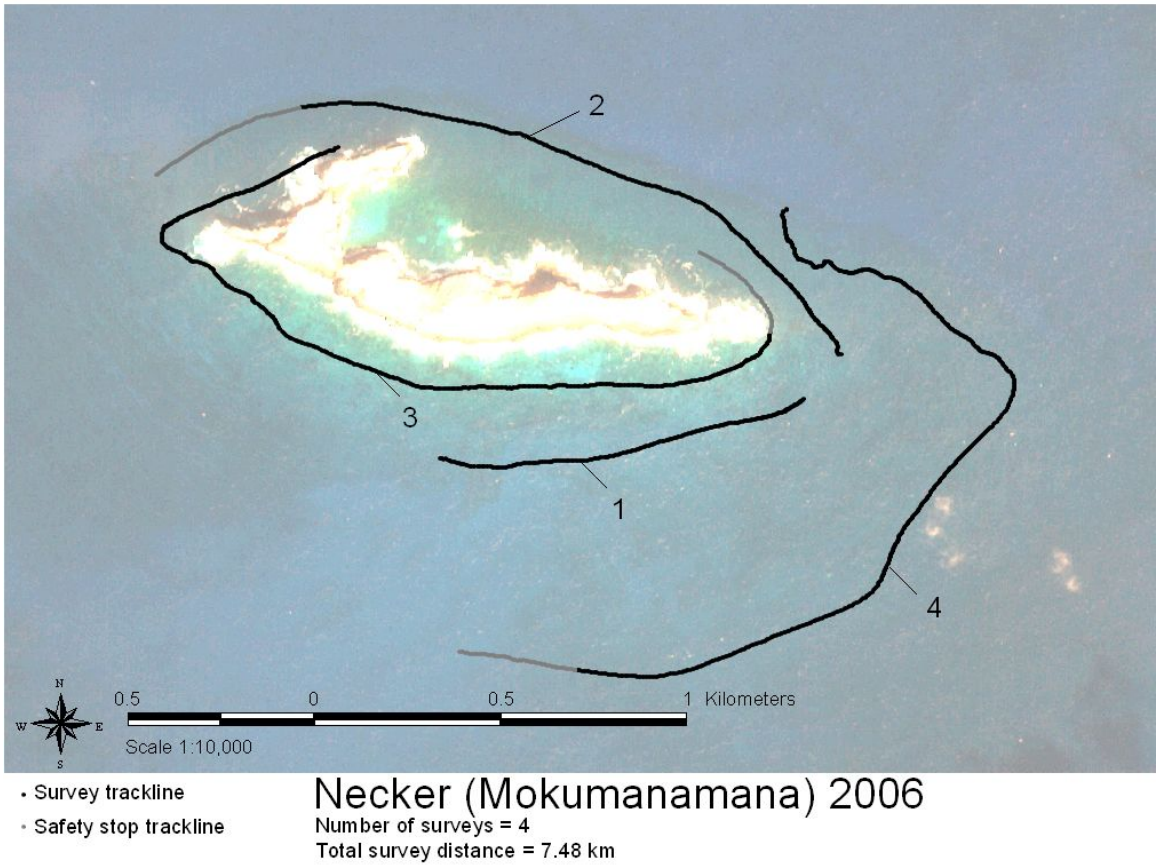

Figure B.5.2. Map showing location of towboard tracks at Necker Island.

Appendix C: French Frigate Shoals

C.1. Oceanography and Water Quality

In total, ten instruments were deployed and seven instruments were recovered at French Frigate Shoals (FFS). One Coral Reef Early Warning System (CREWS) buoy and CREWS buoy anchor was removed and replaced (Fig. C.1.1). The addition of two pad eyes on the CREWS buoy anchor will allow for a 6-year anchor deployment eliminating the need to tow in an anchor during the next two Reef Assessment Monitoring Program (RAMP) cruise swaps. Five subsurface temperature recorders (STR) were recovered; two in shallow backreef habitat on the northwestern and southern sides of the atoll, one at La Perouse Pinnacle, one in patch reef habitat in the center of the atoll, and one attached to the CREWS buoy anchor. An additional temperature sensor (SBE39) was attached to the CREWS buoy arm serving as a backup data set incase of buoy malfunction. Eight STRs were deployed; six deployments at existing locations, one new location proximate to Rapid Ecological Assessment (REA) site 12 at the southern end of the atoll, and another deployed at Rapture reef. These two new deployments form a depth transect down the southern edge of the reef. Diurnal and semidiurnal cold water pulses have been noted at similar southern reef locations along the Hawaiian Ridge that may play an important role in the ecosystem dynamics. Two ecological acoustic recorders (EAR) were also deployed. One EAR is colocated with the STR at Rapture Reef and is within 10 m of one of Carl Meyer's listening stations, while the other EAR was deployed 50 m southwest of the CREWS buoy, which is also in close proximity to one of Jim Maragos' permanent coral transects.

Twenty-six shallow water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of FFS following the 30-m contour. At 5 of these locations, water sample profiles were performed for a total of 23 water samples measuring chlorophyll and nutrient levels. All water sample profiles were conducted concurrently with CTD casts.

Preliminary Results

Figure C.1.2. shows temperature data obtained from four locations around FFS; three located in shallow (2 m), backreef habitat in the north, central, and southern portions of the atoll, and one from La Perouse Pinnacle (4 m). Intercomparison of the timeseries data shows similar seasonal temperature fluctuations, with the warmest temperatures occurring from August to September and the coolest from February to March. Intraseasonal variance, however, is distinctly different between shallow, backreef temperature data and data obtained from La Perouse. High frequency fluctuations are observed throughout each of the backreef timeseries plots, likely owing to diel heating and cooling of upper surface waters. In comparison, temperature data from La Perouse shows considerably less high frequency fluctuations, although given the morphologic differences between sensor locations this is not a surprising result. La Perouse is located to the far west of FFS's crescent shape, and is therefore exposed to increased wind and wave energy compared to backreef locations, resulting in a more turbid, well mixed water

column. Figure C.1.3. shows temperature data from the central backreef (red) and La Perouse (black) plotted concurrently to highlight the morphologic and depth dependent variability between data sets.

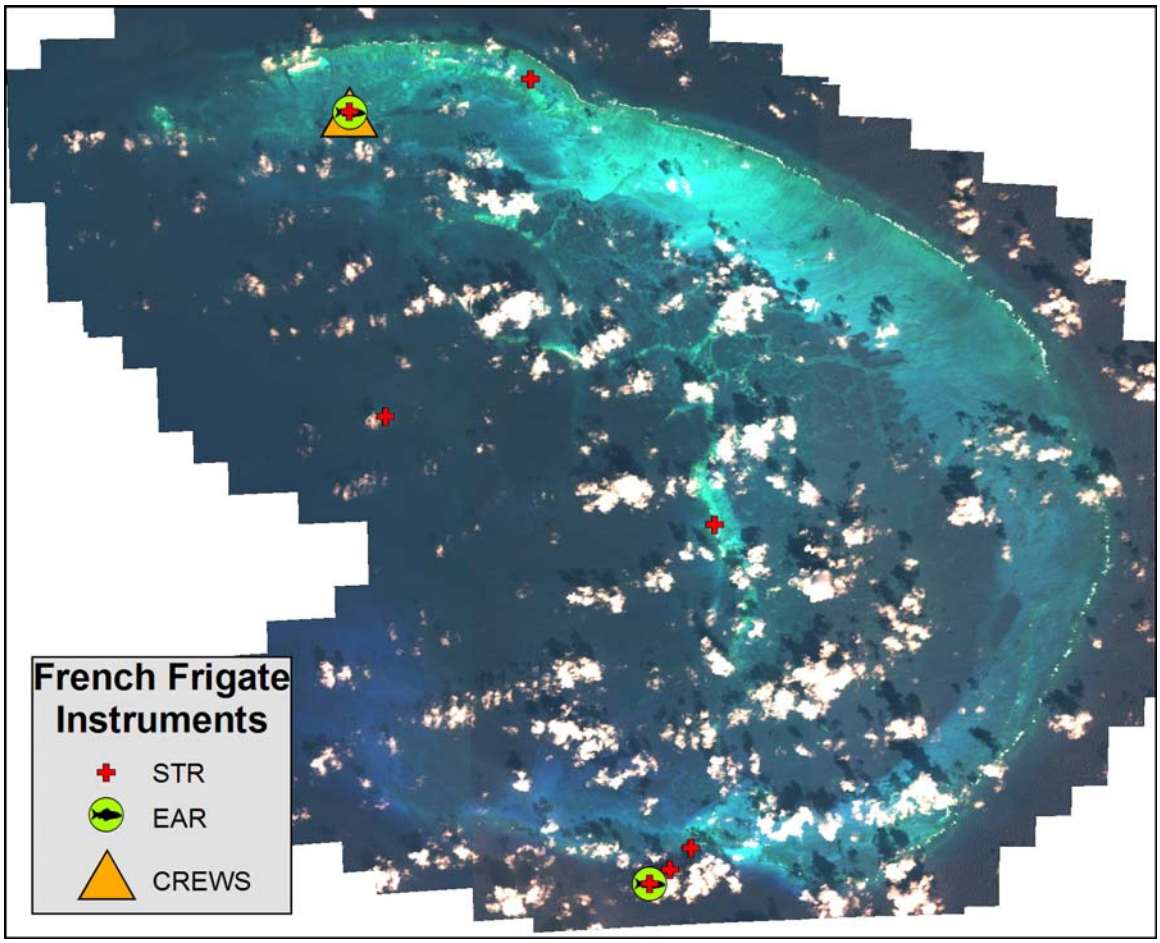

Figure C.1.1. IKONOS satellite image of French Frigate Shoals depicting instruments deployed during HI0611.

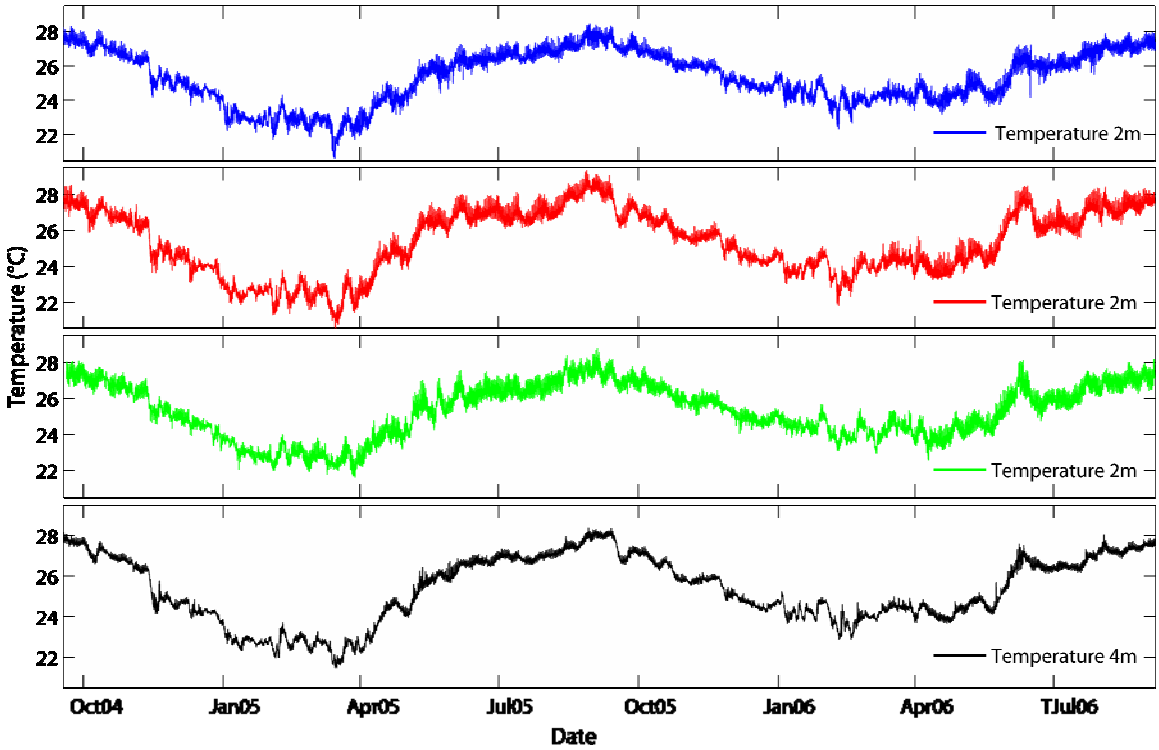

Figure C.1.2. Temperature data obtained from four STR locations around French Frigate Shoals; north backreef (first panel), central backreef (second panel), southern backreef (third panel), and La Perouse (fourth panel).

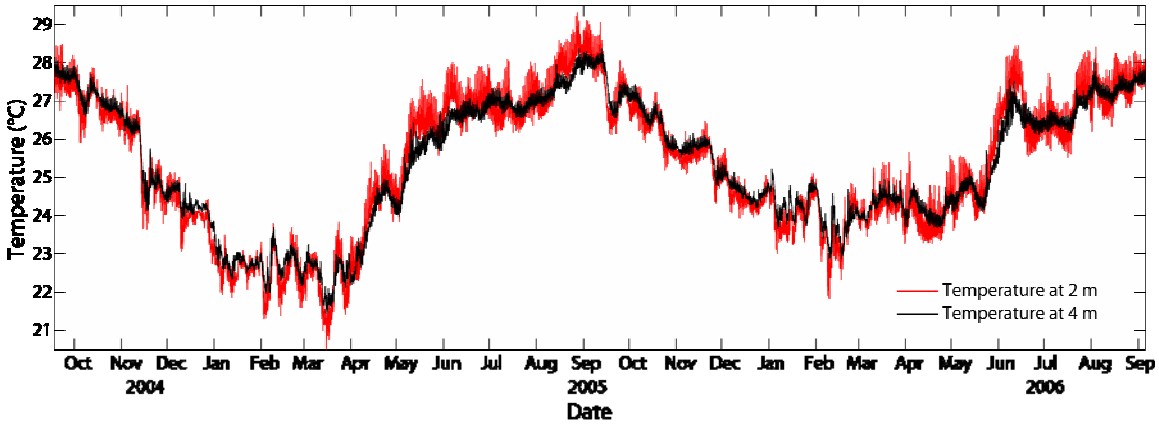

Figure C.1.3. Temperature data from the central backreef (red) and La Perouse (black) plotted concurrently to highlight morphologic and depth dependent variability between locations.

C.2. Rapid Ecological Assessment (REA) Site Descriptions

FFS-30
September 4, 2006

North; south of Tern Island; lagoonal patch reef, with moderate topographic relief. Depth range: 8.5 –10.5 m. Northwest lagoon reef with moderately high topographical relief; visibility ~6.5 m. Pavement/turf and pavement/cca comprised over 58% of benthic cover. Permanent transects installed by Greta Aeby in 2005 targeting *A. cytherea* were not found, although large tables were present in the area. Permanent transect installed along top and side of reef, dropping to rubble along base. The shallow lagoonal reef waters are characterized by *Porites lobata*. Turf algae, *Halimeda velasquezii*, crustose coralline red algae, and *Microdicyton setchellianum* were common in photoquadrats. *Martensia fragilis*, branched coralline red algae, and *Halimeda discoidea* were also recorded. *Haloplegma duperreryi*, *Caulerpa taxifolia*, a species of *Dictyota*, and *Caulerpa webbiana* were found during the random swim. Coral cover was moderate (18.6%); dominated by *Porites* sp; other corals present on transects included: *Acropora valida*, and *Porites evermanni/lutea*. Also, *A. humilis* was found to be common with and along the transect belt. Dominated by highly fissioned *P. lobata*. Eleven scleractinian species enumerated within 50 m^2 belt. One additional scleractinian species observed outside belt transects.

Coral disease and health assessment: Three cases of possible trematodiasis with pigmentation response on *P. lobata* and five cases of compromised health (partial mortality most probably due to predation) on *P. lobata* and *P. lutea*. This site was also characterized by high parrotfish abundance and diversity, lots of small surgeons, such as *Acanthurus nigrofuscus, A. nigroris, Ctenochaetus strigosus* and a few *C. hawaiiensis. Acanthurus triostegus* was forming big schools grazing. Overall, surgeons and parrotfish were dominant.

FFS-21
September 4, 2006

West-northwest, patch reef; depth range: 7–10.5 m. Spur-and-groove system. Greta Aeby's permanent transect placed in 2005 was found and resurveyed. First transect compass heading 90^o, second transect compass heading 120^o. Moderate current, visibility ~20 m. The lagoonal reef was characterized by *Acropora* table corals. Also, turf algae, *Halimeda velasquezii*, and crustose coralline red algae were the dominant algal forms found inside sampled photoquadrats. *Halimeda discoidea* was also observed. High current prevented an extensive random swim, but one individual of *Caulerpa taxifolia* was found. Relatively high live coral cover (50.9%), because of extensive development of tabular *Acropora cytherea*, were marked with cable ties by Aeby. Also, abundant encrusting *Porites lobata*, highly fissioned. Nine anthozoan species (eight scleractinian and *Palythoa*) enumerated within 50 m^2 belt. One additional scleractinian species observed outside belt transects.

Coral disease and health assessment: Three cases growth anomalies and three cases of white syndrome on *A. cytherea*; two cases of tissue necrosis on *Porites lobata*, and one possible case of coralline algal fungal disease. This site was dominated by surgeons, and triggerfish as well. Particularly abundant were *Chaetodon trifascialis*, and *Acanthurus triostegus* were once again forming large (100's) schools grazing on the reef. A few large predators were seen, such as *C. melampygus*, *A. virescens*. One diver observed three morwongs.

FFS-H6
September 4, 2006

North, north of Tern Island. Ocean fringing reef, spur and groove system. Depth range: 8.5–10.6 m. Permanent transect markers installed by Jim Maragos were not found, therefore a new permanent transect was installed. Compass heading 160°. Algae such as turf , *Halimeda velasquezii*, *Microdictyon setchellianum*, crustose coralline red algae, and *Halimeda discoidea* were common in photoquadrats. *Turbinaria ornata* and *Lobophora variegata* were also recorded. During the random swim, we found *Halimeda opuntia, H. distorta*, *Neomeris* sp., *Haloplegma duperreyi*, *Gibsmithia hawaiiensis*, and *Dictyosphaeria versluysii*. Live coral cover was moderate (23.5%), dominated by low-profile and encrusting, colonies of *Porites lobata*. *Acropora cytherea, Pocillopora meandrina*, and *Montipora capitata* were also enumerated along the point-intercept transects. Dominated by highly fissioned *P. lobata*, with numerous *A. cytherea* recruits <40 cm. Thirteen anthozoan species (twelve scleractinian and *Palythoa*) enumerated within 50 m^2 belt. One additional scleractinian species observed outside belt transects.

Coral disease and health assessment: Three cases of trematodiasis were enumerated on *Porites lobata* and *P lutea*, additionally, five cases of compromised health as a result of predation; four of these cases on *Pocillopora*, *Porites*, *Montipora*, and *Pavona*, because of *Acanthaster*; one additional case of predation on *Porites lobata* possibly by parrot fishes. This site was characterized by apex predators. We saw *Caranx ignobilis* (one large individual was accompanying all divers on their safety stops), lots of *C. melampygus*, a *C. orthogrammus*. John Mitchell saw an enormous moray eel, and the fish team saw three white tip reef sharks, a grey reef shark, a big school of very large (~60 cm for the largest) *Naso caesius*, a large school of taape, quite a few big mu, and lots of kyphosids.

FFS-12
September 5, 2006

South. Depth range: 9.4–10.1 m. Relocated and resurveyed Greta Aeby's permanent transect. Coral cover was relatively high (65%); mainly tabular *Acropora cytherea*. South lagoon reef with moderately low topographical relief; visibility ~100 feet. Found and used permanent transects (2, 25 m) installed by Greta Aeby in 2005. Compass heading 270°. Turf and crustose coralline red algae grew on dead coral skeletons and were essentially the only algae recorded within photoquadrats, although a small amount of encrusting *Lobophora variegata* was also documented. Numerous large

individuals of *Gibsmithia hawaiiensis* were observed among crevices in the coral community, and *Haloplegma duperreyi* was luxuriant on the underside of dark overhangs. A species of *Neomeris*, *Halimeda velasquezii*, *H. discoidea*, and *Martensia fragilis* were also collected. Extensive beautiful *A. cytherea* flats composed of numerous large, overlapping tabular colonies. Only two scleractinian species enumerated within 50 m^2 belt (*A. cytherea* and *Porites lobata*). No additional scleractinian species observed outside belt.transects.

Coral disease and health assessment: Tags and markers visible labeling diseased colonies. Within area surveyed (~300 m^2) 22 cases of white syndrome and 3 cases of growth anomalies on *Acropora cytherea*. Interestingly, growth anomalies were clustered on a few colonies at the beginning of the first transect. White syndrome was nearly three times more prevalent along the second transect than on the first one. Overall there was a good abundance of fish at this site. Large schools of mu, *Mulloidichthys vanicolensis*, and *Chromis ovalis*, were seen swimming around. Also a white tip shark some uluas, uku, *A. furca*, lots of *M. berndti*, *P. meeki*, *S. spiniferum*, taape and *C. strigosus* were present. The great visibility made it easy to see all these. Also, good diversity of wrasse, surgeons and parrotfish, lots of *C. trifascialis*.

FFS-34
September 5, 2006

South, Depth range: 9.5–10 m. Low relief, oversized, carbonate rubble/sand field. Relatively low coral cover (2.9%); turf-colonized rubble and dead coral surfaces comprised over 83% of benthic cover, and visibility was ~40 feet. Installed new permanent transects (2, 25 m). Compass heading 210°.This site consisted of scoured pavement with large individuals of *Ganonema farinosum* that became visible to divers halfway down in the water column. Coral cover was low, and the edges of crisp, epiphytized blades of *Microdicyton setchellianum* appeared as crescents that formed dense beds on the seafloor. Within photoquadrats, turf algae, crustose coralline red algae, *Microdictyon setchellianum*, *Halimeda discoidea*, *H. velasquezii*, *Lobophora variegata*, and tiny blades of a species of *Padina* were common. A diminutive species of *Dictyota* was also recorded. In addition to *Ganonema*, *Dictyosphaeria versluysii*, a species of *Neomeris*, and *Haloplegma duperreryi* were encountered during the random swim. Twelve scleractinian species enumerated within disease survey area (300 m^2). Also, eleven anthozoan species enumerated within 50 m^2 belt (10 scleractinian and *Palythoa*). One additional scleractinian species observed outside belt transects.).

Coral disease and health assessment: Within area surveyed (~300 m^2), three cases of compromised health on *Pocillopora meandrina* and *Pocillopora ligulata*, because of *Acanthaster* predation. The following fish where recorded by the fish team: Uku, large schools of furca, skinny ulua and one skinny barracuda, good surgeonfish diversity, damselfish and wrasse relatively abundant, not much abundance/diversity overall. Not much shelter.

FFS-R29
September 5, 2006

Southeast lagoon patch reef with moderate topographical relief; visibility ~30 feet. Transect depth 9–15m. Installed new permanent transects (2, 25 m). Compass heading 300^{o} (transect 1) and 270^{o} (transect 2). This lagoonal patch reef had poor visibility. Turf algae, *Halimeda discoidia*, *H. velasquezii*, *H. opuntia*, crustose coralline red algae, branched coralline red algae, and *Lobophora variegata* were recorded in photoquadrats. *Bryopsis pennata*, *Chondrophycus parvipapillatus*, and a gooey red blade (what Izzie Abbott had previously called *Predaea weldii*, but is possibly a species of *Nemastoma*?) were found during the random swim. The patch reef was composed of rugose carbonate with abundant assemblage of *Pocillopora damicornis* and *Porites lobata/evermanni*. *Cyphastera ocellina* commonly observed, also several colonies of *Porites brighami*, as well as one colony of *Acropora cytherea*. Percent live coral cover was 9.8% and turf algae over dead coral surfaces amounted to >45% of benthic cover. The site slope upwards from 15 to 9 m. Scleractinian species were enumerated within 50 m^2 belt. One additional scleractinian species observed outside belt transects.

Coral disease and health assessment: Within area surveyed (~300 m^2) five cases of trematidiasis on *Porites lobata* and *Porites evermanni*/*lutea*. Overall, fish abundance was characterized by large uluas and dominated by small parrotfish, again not much cover for fish to hide in. Small surgeons, wrasse, and parrotfish were also dominant.

FFS-R46
September 30, 2006

La Perouse Pinnacles; West; central lagoon. Transect depth range: 6.4– 10.7 m. The site was characterized by complex and substantial topographic complexity with many oversized rocky boulders, gaps, and cracks. Surge was high. We surveyed pins installed by Jim Maragos for transect 1, and installed new permanent transect markers along transect 2 (shallower depth). This site's coral, turf algal, and coralline red algal cover were high. Except for large beds of *Asparagopsis taxiformis* that commonly occurred, macroalgae were relatively scarce. We recorded an encrusting form of *Lobophora variegata*, tiny individuals (one segment) of *Halimeda velasquezii*, *Gibsmithia hawaiiensis*, *Dictyota friabilis* growing among the branches of non-geniculate branched calcified red algae, *Caulerpa webbiana*, *Bryopsis pennata*, and a species of *Peyssonnelia*. Corals growing directly on rocky ridges. Moderately high percent live coral cover (37.8%); dominated by encrusting *Porites lobata* (59%). Transect 1 dominated by encrusting *Porites lobata*; *Acropora valida* abundant along transect 2. Good coral diversity. Ten scleractinian species enumerated within 50 m^2 belt transects. Three additional scleractinian species (*Acropora humilis*, *Pavona varians*, and *Leptastrea purpurea*) observed in larger area outside belt transects. Other scleractinians enumerated along the point intercept transect included: *Acropora cytherea*, *A. valida*, *Pocillopora meandrina*, *Montipora capitata*, *M. patula*, *Pavona duerdeni*, and *Porties brighami*. Coloinies of *Psammocora nierstraszi* were observed outside the survey area. Nonetheless this is the first record of this species during the current RAMP cruise.

Coral disease and health assessment: Within the area surveyed (survey plot ~300 m^2; survey depth range: 5–9 m) one case of bleaching on *Porites lobata*, three cases of tissue loss on *Porties lobata*, and nine cases of compromised health condition on *P. lobata* and *P. evermanni*, involving pigmentation responses. This site was dominated by surgeonfishes, particularly *Acanthurus triostegus, Acanthurus achilles,*and *Ctenochaetus strigosus.* Also there was a large school of *Melichthys niger* and some aggressive *Kyphosus bigibbus* in the area. Stationary Point Count (SPC) diver saw primarily *Melichthys niger.*

FFS-32
September 30, 2006

North central lagoon, arc shell patch reef, moderately high topographical relief. Transect depth range: 4.9–9.8 m. Relatively low-profile patch reef, with moderate topographic complexity. Installed new permanent transects (2, 25 m). Highly bioeroded carbonate/arc shells. This lagoonal reef site was interesting because the algal community at the beginning of our transect lines differed dramatically from the algal community at the end of the transect lines. Along the first transect, we recorded a *Microdictyon setchellianum* dominated environment that also contained abundant turf algal communities. By the end of the second transect, *M. setchellianum* had almost disappeared, and the substrate was dominated by turf algae, crustose coralline red algae, an encrusting form of *Lobophora variegata*, and *Halimeda velasquezii*. Other algae found at the site included *Dictyosphaeria versluysii*, non-geniculate branched calcified red algae, *Halimeda opuntia, H. discoidea, Dasya iridescens, Haloplegma duperreyi, Gibsmithia hawaiiensis, Caulerpa peltata, C. racemosa*, and a species of *Neomeris.* Relatively low percent live coral cover (18.6%) was also dominated by encrusting and moderately-fissioned *Porites lobata* (48%), which was the most common coral. Good coral diversity. Ten scleractinian species enumerated within 50 m^2 belt transects. Seven additional scleractinian species (*Acropora cytherea, A. humilis, Montipora incrassata, Leptastrea purpurea, Fungia scutaria, Psammocora nierstraszi,* and *P. stellata*) observed in larger area outside belt transects. Other scleractinians *Montipora capitata, Porites evermanni, Cyphastrea ocellina,* and and *Porties brighami*. Colonies of *Psammocora nierstraszi, Acropora cytherea,* and *A. humilis* were observed outside the survey area.

Coral disease and health assessment: Within the area surveyed (survey plot ~300 m^2; survey depth range: 5–9.5 m) 23 counts of bleaching were observed on *Montipora capitata, M. patula, Pocillopora ligulata,* and *Porites lobata*. Additionally, one case of tissue loss and two cases of trematodiasis were observed on *Porites lobata* and *P. compressa,* respectively. Also, two cases of growth anomalies were detected on *Pocillopora meandrina*. This site was dominated by *Thalassoma duperrey* and small surgeons, particularly *Ctenochaetus strigosus.* SPC diver saw a couple of *Aprion virescens,* some small *Caranx melampygus,* and a large number of *Naso unicornis.*

FFS-33
September 30, 2006

Northern sector of central lagoon; patch reef. Transect depth range: 8.8–11.0 m. Low-profile patch reef, with relatively topographic complexity. Installed new permanent transects (2, 25 m). Rocky and carbonate substrates interspersed with sand pockets. This coral rich lagoonal reef flat had a very uniform algal community consisting of turf algae, *Halimeda velasquezii*, crustose coralline red algae, and encrusting *Lobophora variegata*. Occasional individuals of non-geniculate branched calcified red algae, *Haloplegma duperreyi*, *Halimeda discoidea*, *H. gracilis*, *Caulerpa webbiana*, *Microdictyon setchellianum*, cyanophytes, and species of *Nemastoma*, *Neomeris*, and *Peyssonnelia* were encountered. Moderate percent live coral cover (29.4%); analogously to previous two sites, percent live coral cover heavily dominated by encrusting and highly-fissioned *Porites lobata* (83%). Turf algae growing on the carbonate pavement, dead coral surfaces, and rubble, comprised nearly 40% of the benthic cover. *Porites lobata*, making colony counts and size class assessments for this species highly interpretive. Good coral diversity. Twelve scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Montipora incrassata* and *Pavona duerdeni*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the area surveyed (survey plot ~300 m^2; survey depth range: 8.8–9.1 m) two counts of bleaching were observed on *Montipora capitata* and *Porites compressa*. Additionally, one case of tissue loss and six cases of trematodiasis were observed on *Porites lobata* and *P. compressa*. Also, 22 cases of compromised health condition were detected on *P. lobata*, *P. compressa*, and *P. evermanni*, involving pigmentation responses with filamentous algal overgrowth. This site was dominated by *Thalassoma duperrey* and *Ctenochaetus strigosus*. SPC diver saw a lot of *Naso lituratus* and lots of large uhu, *Chlorurus perspicillatus*, *Chlorurus sordidus*, and *Scarus dubius.*

FFS-35
October 1, 2006

Central sector of central lagoon; patch reef. Transect depth range: 13–16.2 m; visibility: ca. 15 m. Western end of linear reef. No permanent transects installed, as not a long-term monitoring site. This lagoonal reef exhibited high coral cover, and algal diversity was high. Exceptionally large blades of a possible species of *Nemastoma* formed clusters around the base of many coral branches. In addition to *Nemastoma*, turf algae, crustose coralline red algae, *Halimeda gracilis*, *H. opuntia*, *H. velasquezii*, encrusting *Lobophora variegata*, and a creeping species of *Codium* were found inside photoquadrats. During the random swim we found *Dasya kristeniae*, *Halimeda distorta*, *H. discoidea*, *Haloplegma duperreyi*, *Gibsmithia hawaiiensis*, *Caulerpa taxifolia*, non-geniculate branched calcified red algae, and a species of *Peyssonnelia*. Moderately high percent live coral cover (35%); heavily dominated by encrusting *Porites compressa* (64.5%); highly-fissioned *P. lobata* common; counts and size classes highly interpretive. Eight scleractinian species enumerated within 50 m^2 belt transects. Two additional

anthozoan species (*Pocillopora eydouxi* and *Palythoa sp.*) observed in larger area outside belt transects. Other scleractininas enumerated along the line-intercept transects included: *Porites lobata* and *Pocillopora meandrina*. Turf algae growing on the carbonate pavement, dead coral surfaces, and rubble, comprised over 40% of the benthic cover. Additionally, macroalgae, including *Halimeda*, represented over 10% of the biological benthos.

Coral disease and health assessment: Within the area surveyed (survey plot ~300 m^2; survey depth range: 13–15.7 m) three counts of bleaching were observed on *Montipora capitata* and *Porites lobata*. Additionally, one case of tissue loss was observed on *Porites lobata*. Also, 29 cases of compromised health condition were detected on *P. lobata*, *P. compressa*, and *P evermanni*, involving pigmentation responses with focal to multifocal filamentous algal overgrowth. This site was dominated by herbivores, particularly *Scarus psitticus, Chlorurus sordidus,* and *Ctenochaetus strigosus*. There were an abundance of *Priacanthus meeki,* and one diver also saw *Heteropriacanthus cruentatus.* SPC diver saw *Chlorurus sordidus, Melichthys niger, Naso lituratus,* and a couple of *Aphareus virescens.*

C.3. Benthic Environment

C.3.1. Algae

Quantitative algal surveys were conducted at 10 sites located on the northwestern and southeastern sides of French Frigate Shoals, including two sites located north and south of Tern Island (FFS-30, FFS-21, FFS-H6, FFS-12, FFS-34, FFS-R-29, FFS-R-46, FFS-32, FFS-33, FFS-35). Geomorphically, sites varied greatly from lagoonal patch reefs, fringing reefs, spur and groove systems to low relief, oversized, carbonate rubble/sand fields. A site adjacent to La Perouse Pinnacles contained high topographic complexity; oversized rocky boulders, gaps with a strong surge. Prominent algal species found at most sites included *Halimeda velasquezii, H. discoidea, H. opuntia*, and *Microdictyon setchellianum.* Brown algae were not commonly seen, although *Lobophora variegata* was present in all sites. Species of *Dictyota, Padina*, and *Turbinaria ornata* were only collected from single sites. Red algae found at the sites included *Haloplegma duperreyi, Gibsmithia hawaiiensis*, non-geniculate calcified branched red algae, species of *Peyssonnelia*, and species of *Nemastroma. Martensia* was only found at one site. Overall, 15 species of green algae, 11 species of red algae, and 5 species of brown algae were collected. Microscopic examination of epiphytes will increase the number of species collected substantially.

Table C.3.1.1: Algal genera or functional groups recorded in photoquadrats at French Frigate Shoals. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	FFS-30	FFS-21	FFS-H6	FFS-12	FFS-34	FFS-R29	FFS-R-46	FFS-32	FFS-33	FFS-35
GREEN ALGAE										
Codium	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	**8.3**
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**
Dictyosphaeria	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.5**	**0.0**	**0.0**
Halimeda	*75.0*	*75.0*	*83.3*	*0.0*	*16.7*	*91.7*	*8.3*	*91.7*	*91.7*	*91.7*
	2.8	**2.8**	**2.2**	**0.0**	**3.0**	**3.1**	**4.0**	**4.2**	**2.7**	**2.2**
Microdictyon	*25.0*	*0.0*	*50.0*	*0.0*	*33.3*	*0.0*	*0.0*	*50.0*	*0.0*	*0.0*
	3.3	**0.0**	**3.7**	**0.0**	**2.3**	**0.0**	**0.0**	**2.2**	**0.0**	**0.0**
RED ALGAE										
Asparagopsis	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*

	FFS-30	FFS-21	FFS-H6	FFS-12	FFS-34	FFS-R29	FFS-R-46	FFS-32	FFS-33	FFS-35
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**	**0.0**
Non-geniculate calcified branched red algae	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*50.0*	*8.3*	*8.3*	*16.7*	*0.0*
	3.0	**0.0**	**0.0**	**0.0**	**0.0**	**3.2**	**2.0**	**3.0**	**5.0**	**0.0**
crustose coralline algae	*58.3*	*83.3*	*75.0*	*41.7*	*50.0*	*75.0*	*91.7*	*91.7*	*100.0*	*100.0*
	2.8	**2.3**	**3.2**	**2.0**	**3.3**	**2.7**	**2.2**	**3.5**	**2.6**	**1.4**
Nemastoma	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**
BROWN ALGAE										
Lobophora	*0.0*	*0.0*	*8.3*	*8.3*	*66.7*	*16.7*	*16.7*	*91.7*	*66.7*	*25.0*
	0.0	**0.0**	**4.0**	**3.0**	**2.4**	**4.0**	**3.0**	**3.1**	**3.5**	**3.0**
Padina	*0.0*	*0.0*	*0.0*	*0.0*	*25.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Turbinaria	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
FUNCTIONAL GROUPS										
turf algae	*75.0*	*91.66667*	*100*	*75.0*	*100.0*	*100.0*	*100.0*	*100*	*100*	*100.0*
	1.0	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.3**	**1.0**	**2.1**

Table C.3.1.2: Putative algal species found at French Frigate Shoals. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis.

List of putative macroalgal species collected (all samples required microscopic analysis before species can be confirmed (one sample per site)

	FFS-30	FFS-21	FFS-H6	FFS-12	FFS-34	FFS-R29	FFS-R-46	FFS-32	FFS-33	FFS-35
GREEN ALGAE										
Bryopsis pennata						X	X			
Caulerpa peltata								X		
Caulerpa serrulata								X		
Caulerpa taxifolia	X	X								X
Caulerpa webbiana	X						X		X	

Codium sp.										X
Dictyosphaeria versluysii			X		X			X		
Halimeda spp.							X			
Halimeda discoidea	X	X	X	X	X	X		X	X	X
Halimeda distorta			X							X
Halimeda gracilis									X	X
Halimeda opuntia			X			X		X		X
Halimeda velasquezii	X	X	X	X	X	X		X	X	X
Microdictyon setchellianum	X		X		X			X	X	
Neomeris sp.			X	X	X			X	X	
RED ALGAE										
Asparagopsis taxiformis							X			
Non-geniculate calcified branched red algae	X					X	X	X	X	X
Chondrophycus parvipapillatus						X				
Dasya iridescence								X		
Dasya kristeniae										X
Ganonema farinosum					X					
Gibsmithia hawaiiensis			X	X			X	X		X
Haloplegma duperreyi	X		X	X	X			X	X	X
Martensia sp.	X			X						
Nemastoma sp.						X			X	X
Peysonnellia spp.							X		X	X
BROWN ALGAE										
Dictyota spp.	X				X					
Dictyota friabilis							X			
Lobophora variegata			X	X	X	X	X	X	X	X
Padina spp.					X					
Turbinaria ornate			X							

C.3.2. Corals

Coral REA surveys were conducted at ten sites. Of these, nine were among the twelve sites selected by Coral Reef Ecosystem Division (CRED) and partners in 2003 for long-term monitoring. Three long-term monitoring sites could not be resurveyed in 2006 (FFS-22, FFS-23, and FFS-R30) because of inclement sea conditions on October 1 that affected most shallow-water exposures throughout the atoll. Instead, an alternative, deeper site conducive to safer diving was surveyed, FFS-35. This site had not been previously assessed during CRED or *Rapture* cruises.

The most recent surveys by CRED at French Frigate Shoals were conducted in September 2004, during which 11 of the 12 long-term monitoring sites were visited. In 2004, site FFS-22, a patch reef in the northern lagoon, was the single long-term site that was not surveyed; consequently, CRED has no quantitative benthic data for FFS-22 since 2003. FFS-22 also was not surveyed for corals and coral disease by Dr. Evelyn Cox and Dr. Greta Aeby in September 2005 during the NWHI Ecosystem Reserve cruise, nor were sites FFS-R46 and FFS-R30. However, CRED's other nine long-term monitoring sites were surveyed by Cox and Aeby in September 2005.

In 2005, Dr. Aeby installed permanent transect (2, 25 m) markers at sites FFS-12, FFS-21, and FFS-30. Markers at the first two sites were relocated during the present surveys and used as a guide for transect deployment. However, markers at FFS-30 were not relocated by the fish team within a 5-minute search period. In 2002, Dr. Jim Maragos installed permanent transects (2, 25 m) at R46, La Perouse Pinnacles. Only one of the permanent transects was relocated and used as a guide for transect line deployment. Permanent transect markers were installed along the first two transects by members of the REA fish team this year at the remaining surveyed long-term monitoring sites and at FFS-30, with the intention of reducing error because of spatial imprecision on future surveys. At FFS-R46, one (25 m) permanent transect was installed. Global Positioning System (GPS) site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded after descending, in order to facilitate relocating the markers on future surveys.

C.3.2.1 Coral populations

A total of 2408 colonies belonging to 20 anthozoan taxa were enumerated within belt transects enclosing 500 m^2 benthic substrate (Table C.3.2.1). The most frequently occurring taxa were *Porites lobata, Porites compressa,* and *Acropora cytherea*. Two additional taxa not seen within belt transects were observed within the larger survey area surrounding the transect belts (*Fungia scutaria* and *Pavona varians*).

Table C.3.2.1. Number of anthozoans enumerated within belt transects at French Frigate Shoals during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Taxon	# of colonies	Percent of total
Acropora cytherea	258	**10.7**
Acropora valida	122	5.1
Acropora humilis	7	0.3
Montipora capitata	62	2.6
Montipora patula	60	2.5
Montipora verilli	0	0.0
Montipora flabellate	0	0.0
Montipora turgescens	0	0.0
Montipora incrassate	3	0.1
Pavona duerdeni	60	2.5
Pavona varians	0	0.0
Cyphastrea ocellina	183	7.6
Leptastrea purpurea	23	1.0
Fungia scutaria	0	0.0
Pocillopora damicornis	166	6.9
Pocillopora eydouxi	3	0.1
Pocillopora ligulata	9	0.4
Pocillopora meandrina	196	8.1
Porites brighami	26	1.1
Porites compressa	382	**15.9**
Porites evermanni	35	1.5
Porites lobata	776	**32.2**
Psammocora nierstraszi	2	0.1
Psammocora stellata	3	0.1
Palythoa sp.	32	1.3
Zoanthus pacifica	0	0.0
Total # colonies	2408	100.0
Area surveyed, m^2	500	

Size class distributions of all corals enumerated within belt transects are shown in Figure C.3.2.1. Of the 2408 colonies whose maximum diameter was visually estimated, 53.2% had a maximum diameter <10 cm, and 8.5% had a maximum diameter >40 cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003–2005 surveys.

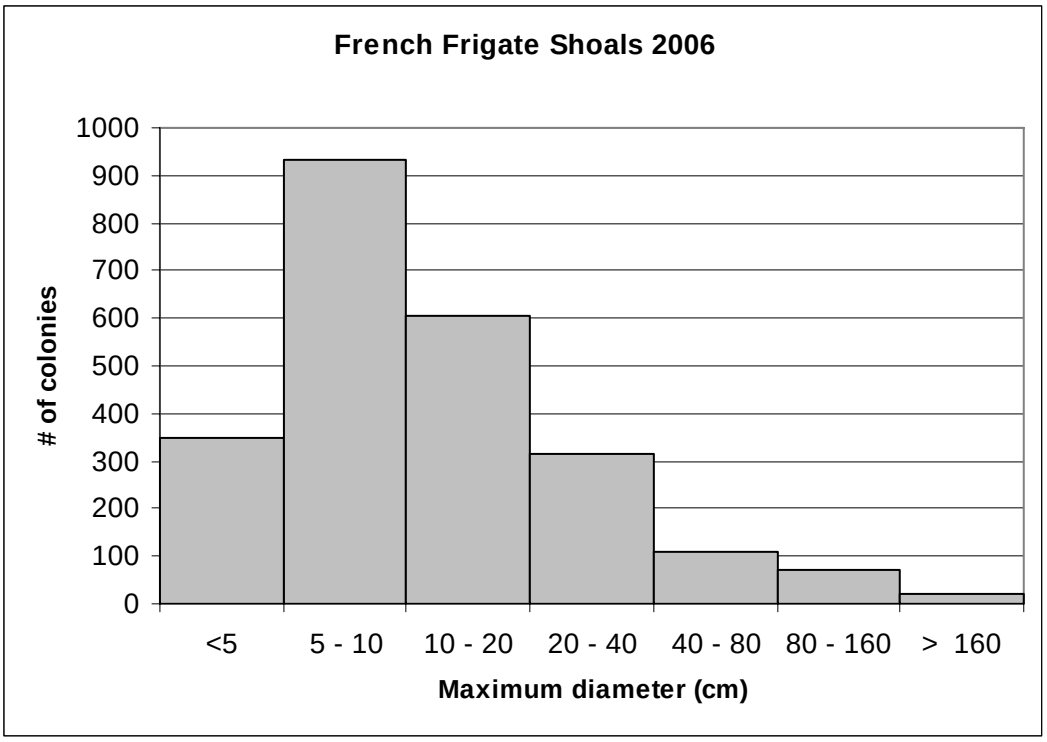

Figure C.3.2.1. Size class distribution of 2408 coral colonies enumerated within belt transects at French Frigate Shoals in 2006.

C.3.2.2. Percent benthic cover

Percent benthic cover surveys at French Frigate Shoals were conducted in concert with the fish, coral population, and algae REA surveys at 10 different sites. The line-intercept methodology quantified a total of 1020 points along 500 m of coral reef communities, including forereef, back reef, and lagoon patch, and bank reefs. Survey-transect depths ranged between 6.4–15.5 m for all reef locales visited. A new REA site, FFS-35, was selected on our last day of surveys (Oct 1, 2006) because of inclement weather conditions. The point-count surveys at French Frigate indicated that the mean percent live coral cover for all sites combined was intermediate: 29.7%. Coral cover in excess of 50% was encountered at sites FFS-12 and FFS-21 on the south and northwest sectors of the atoll, respectively (Fig. C.3.2.2.1). These two sites also exhibited important populations of *Acropora cytherea* (Table C.3.2.2.1). Most of all the other sites visited, including forereefs and all the lagoonal patch and bank reef locales, showed intermediate percent live coral cover (~20–40%). These were predominantly built and dominated by *Porites lobata.* Site FFS-35 in the central lagoon was dominated by branching *Porites compressa* (68%). FFS-H6 was the only site visited exhibiting rather live coral cover; 3%.

Of the 20 or so scleratinian taxa reported for all sites combined at French Frigate Shoals (see above section on coral population dynamics by Kenyon), a total of 15 were enumerated along the line-intercept transects (Table C.3.2.2.2), with *Acropora cytherea* and *Porites lobata* being the most numerically abundant (38.9 and 36.3%, respectively).

Below, Table C.3.2.2.2 provides a complete itemized analysis of percent cover for the different benthic elements enumerated using the line-intercept methodology at French Frigate Shoals. Additionally, Figure C.3.2.2.2 illustrates the contribution of the different scledractinain taxa to the total percent live coral cover.

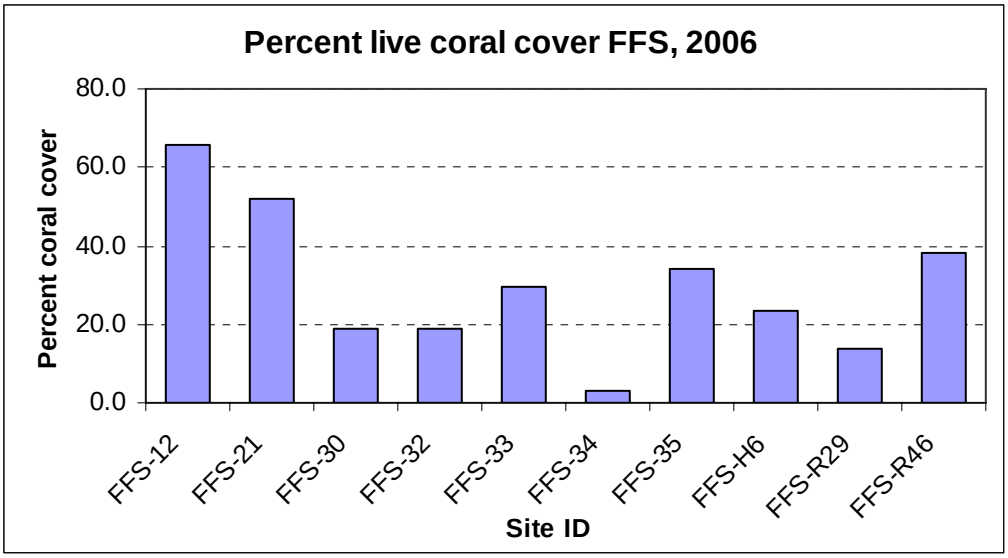

Figure C.3.2.2.1 Summary graph of percent live coral cover at French Frigate Shoals using the point-intercept method during the 2006 REA activities.

Table C.3.2.2.1 Numerical abundance (point counts) of the different coral taxa along the point-intercept transects at French Frigate Shoals during the 2006 NOW-RAMP cruise.

Species	FFS-12	FFS-21	FFS-30	FFS-32	FFS-33	FFS-34	FFS-35	FFS-H6	FFS-R29	FFS-R46	Grand total
Acropora cytherea	67	45						3		3	118
Acropora humilis		1									1
Acropora valida			4							5	9
Cyphastrea ocellina				1					3		4
Montipora capitata				2				1		1	4
Montipora patula					2				1	1	4
Pavona duerdeni									2	2	4
Pocillopora damicornis									1		1
Pocillopora meandrina		1				1	1	1		4	8
Porites brighami				2						1	3
Porites compressa				1	2		24				27
Porites evermanni		1	1	4					3		9
Porites lobata		5	14	9	25	2	10	19	4	22	110
Psammocora stellata					1						1
Grand Total	**67**	**53**	**19**	**19**	**30**	**3**	**35**	**24**	**14**	**39**	**303**

Table C.3.2.2.2 Numerical abundance and percent cover of the different benthic elements enumerated along all the point-intercept transects surveyed at French Frigate Shoals, NOW-RAMP 2006.

Species	Total	% Cover
Acropora cytherea	118	11.6
Acropora humilis	1	0.1
Acropora valida	9	0.9
Cyphastrea ocellina	4	0.4
Montipora capitata	4	0.4
Montipora patula	3	0.3
Montipora verrilli	1	0.1
Pavona duerdeni	4	0.4
Pocillopora damicornis	1	0.1
Pocillopora meandrina	8	0.8
Porites brighami	3	0.3
Porites compressa	27	2.6
Porites evermanni	9	0.9
Porites lobata	110	10.8
Psammocora stellata	1	0.1
Halimeda	48	4.7
Macro-algae	17	1.7
Branched calcifying red algae	2	0.2
Pavement/cca	67	6.6
Pavement/cyano	2	0.2
Pavement/turf	152	14.9
Rubble/cca	21	2.1
Rubble/turf	141	13.8
Dead/cca	47	4.6
Dead/turf	161	15.8
Sand	58	5.7
Sand/turf	1	0.1
Grand Total	1020	

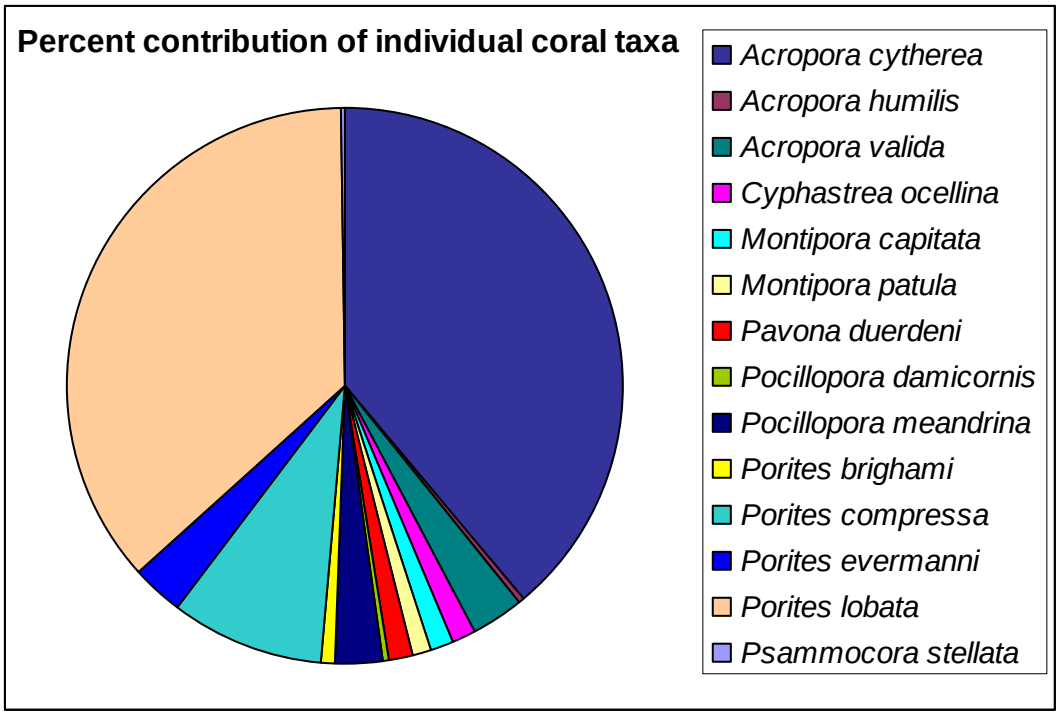

Figure C.3.2.2.2. Percent contribution of the different taxa to the total live coral cover at French Frigate Shoals, NOW-RAMP 2006.

C.3.2.3. Coral disease

At FFS, the coral disease REA surveyed a total area of approximately 3000 m^2 at 10 different sites. Focal paling of several colonies *Porites* spp. and *Pocillopora*, as well as diffuse bleaching of small *Montipora capitata* colonies, was observed. Contrastingly, *Acropora* corals appeared normally pigmented at all the sites visited.

Between 2003 and 2004 Dr. Greta Aeby reported five different diseases states for corals at FFS, including: (1) *Porites* trematoidiasis, (2) *Porites* tissue loss, (3) *Porites* dark tissue thinning, (4) Growth anomalies, and (5) *Acropora* white syndrome. Aside from bleaching, during the 2006 NOW-RAMP cruise, we detected four other types of coral diseases affecting six different scleractinian species, including: (1) Tissue loss, on colonies of *Porties lobata*; (2) trematodiasis, affecting colonies of *Porites lobata*, *P. compressa*, and *P. evermanni*; (3) growth anomalies, on colonies of *Acropora cytherea*, *Pocillopora meandrina*, and *P. ligulata*; and (4) white syndrome affecting colonies of tabular *A. cytherea*.

Bleaching and white syndrome were the most numerically prevalent coral afflictions encountered at FFS; nearly 3 cases per 100 m^2 surveyed.

Equally important as coral diseases were the 88 cases of compromised health state (CHS) observed (Table C.3.2.3.1). Within this health category, four sets of gross morphologies were identified, including: (1) extensive algal overgrowth, affecting

colonies of *Porites lobata* at sites FFS-30, -32, and R46; (2) multifocal discoloration (different to bleaching), again, affecting colonies of *Porites lobata* at sites FFS-21 and –R46; (3) pigmentation responses on colonies of *Porites* spp., and finally (4) *Acanthaster* predation on colonies of *Porites lobata*, *Pavona duerdeni*, *Montipora flabellata*, and *Pocillopora* spp. No tissue samples for histological analyses were also procured.

Table C. 3.2.3.1 Compressed health states.

Type of disease/syndrome	Species	Total
Bleaching	*Montipora capitata*	21
	Montipora patula	2
	Porites compressa	1
	Pocillopora ligulata	1
	Porites lobata	4
Growth anomaly	*Acropora cytherea*	6
	Pocillopora ligulata	1
	pocillopora meandrina	1
Tissue loss	*Porites lobata*	9
Trematodiasis	*Porites compressa*	3
	Porties evermanni	5
	Porites lobata	11
White syndrome	*Acropora cytherea*	25
Compromised health condition		
Algal overgrowth	*Porites lobata*	4
Discoloration	*Porites lobata*	3
Pigmentation response	*Porites lobata*	35
	Porites evernanni	10
	Porites compressa	22
Acanthaster predation	*Porites lobata*	8
	Pavona duerdeni	1
	Montipora flabellata	1
	Pocillopora meandrina	3
	Pocillopora ligulata	1

Below, Figure C.3.2.3.1 illustrates the cumulative number of cases of disease and compromised health states enumerated for all survey areas combined at FFS during the 2006 NOW-RAMP cruise. In addition, Figure C.3.2.3.2 presents an itemized breakdown of the coral taxa exhibiting disease and compromised health states. At a future date, these data will be related to coral colony densities and coral cover in order to numerically estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

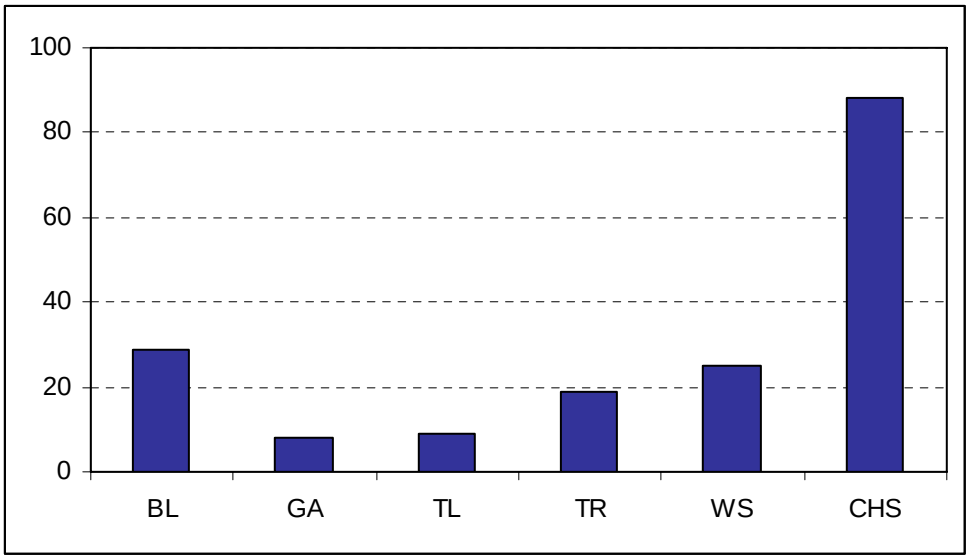

Figure C.3.2.3.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at French Frigate Shoals during the 2006 RAMP cruise. BL: bleaching; GA: growth anomaly; TL: tissue loss; TR: trematodiasis; and CHS: compromised health state, including pigmentation responses, extensive algal overgrowth, discolorations, predation, and other fitness-impairing conditions.

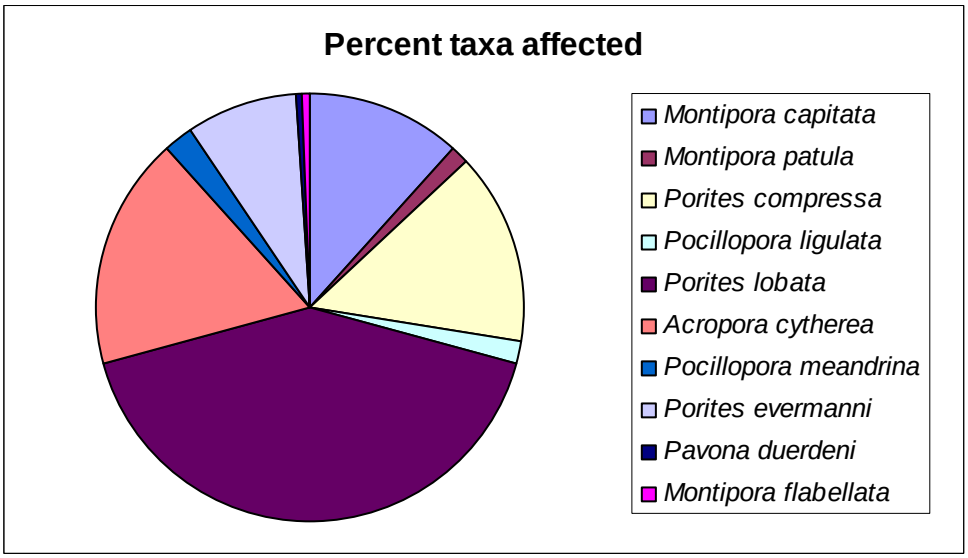

Figure C.3.2.3.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at French Frigate Shoals, NOW-RAMP 2006.

C.3.2.4 USFWS permanent coral transects

Eleven permanent monitoring transects for corals were established at FFS from 2001 to 2002, with six of these resurveyed in 2002 and four resurveyed in September 2006 during the NOWRAMP expedition. These are: Serendipity Hollow, site FFS-11P on the northern backreef; site FFS-16P at the CREWS buoy site in the northern lagoon; site

FFS-3P off the north side of La Perouse Pinnacles in the north central lagoon; and site FFS-2P just west of Disappearing Island off the south reef crest of the atoll. Two other sites were attempted on September 30, site FFS-5P off the fore reef terrace north of Tern Island and site FFS-1P at Shark Island on the northwest backreef near the terminus of the shallow northern end of the perimeter reef of the atoll. However, a large northerly swell at the time of the attempts prevented safe access to and survey of these sites. The remaining five sites were not resurveyed because they were established as part of the Tern Island seawall project in late 2002 and were not a high priority as part of the 2006 surveys.

The pins at all four transects were relocated on 2006, but five of the pins (accounting for half of the transect) at Site FFS-3P were lost and replaced by the REA team along a slightly different alignment. As a consequence, comparisons between 2002 and 2006 were limited to the first half of the transect, although the second half was also censused for corals in 2006 to accommodate future comparisons. Unfortunately not all of the results of earlier surveys at some sites were available on the ship at the time this was prepared to allow full comparisons of 2001, 2002, and 2006 data sets.

In general, all sites showed increases in coral frequency (number of corals per m^2) and most showed increases in coral cover and generic diversity. The CREWS buoy site (FFS-16P) showed increases in mean coral diameter and dramatic increases in the other coral parameters between 2001 and 2006, although the three smallest size classes peaked in 2002. The Serendipity Hollow (FFS-11P) site appears to have experienced wave damage in the recent past based on broken and overturned corals at the site, but coral populations there continued to hold their own and post modest increases in all size classes except the largest two. The La Perouse site (FFS-3P) showed dramatic increases in generic richness, *Acropora*, *Montipora*, and *Psammocora* although there were slight decreases of *Pocillopora* and *Porites.* Corals at the Disappearing Island site (FFS-2P) showed consistent gains in the four smallest size classes and dramatic increases in generic richness over the 5-year period. Moreover, six coral genera noticeably increased in abundance (*Acropora, Pocillopora, Porites, Palythoa, Pavona, Psammocora*) with only one showing a modest decline (*Montipora*).

Figures C.3.2.4.1 through C.3.2.4.4 below graph the changes in the size distribution of all corals during the 4- or 5-year period of monitoring (all data after Maragos, 2001–2006, unpubl.).

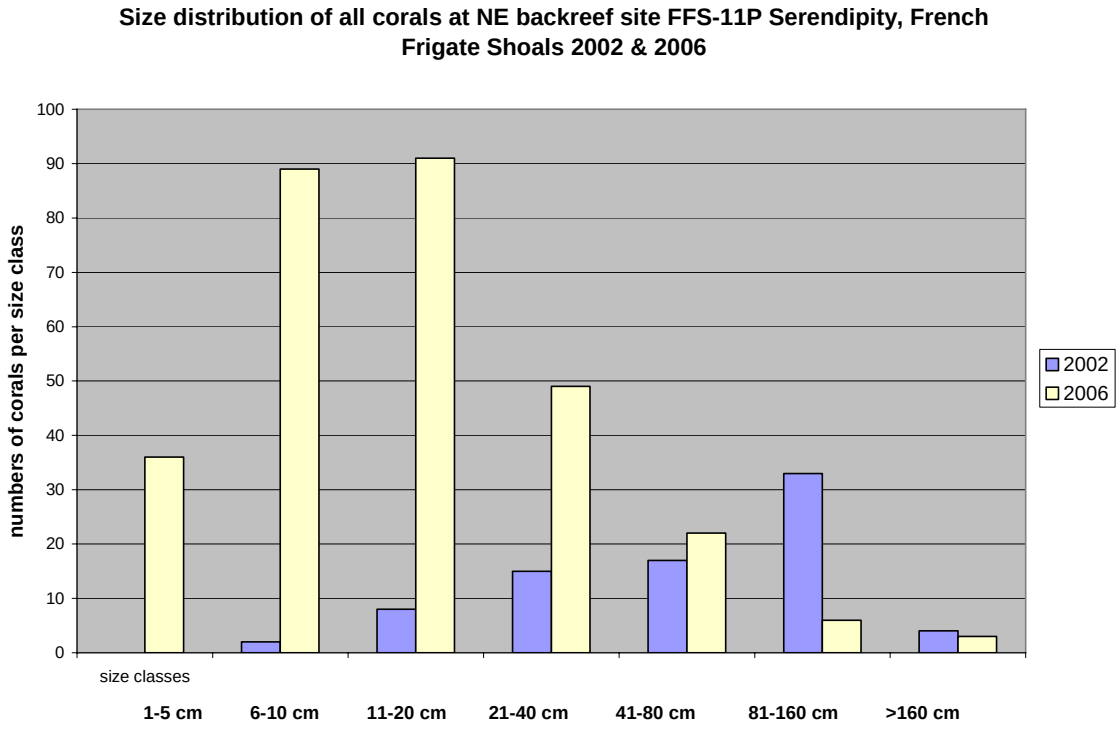

Figure C.3.2.4.1. Size distribution of all corals at French Frigate Shoals site FFS-11P.

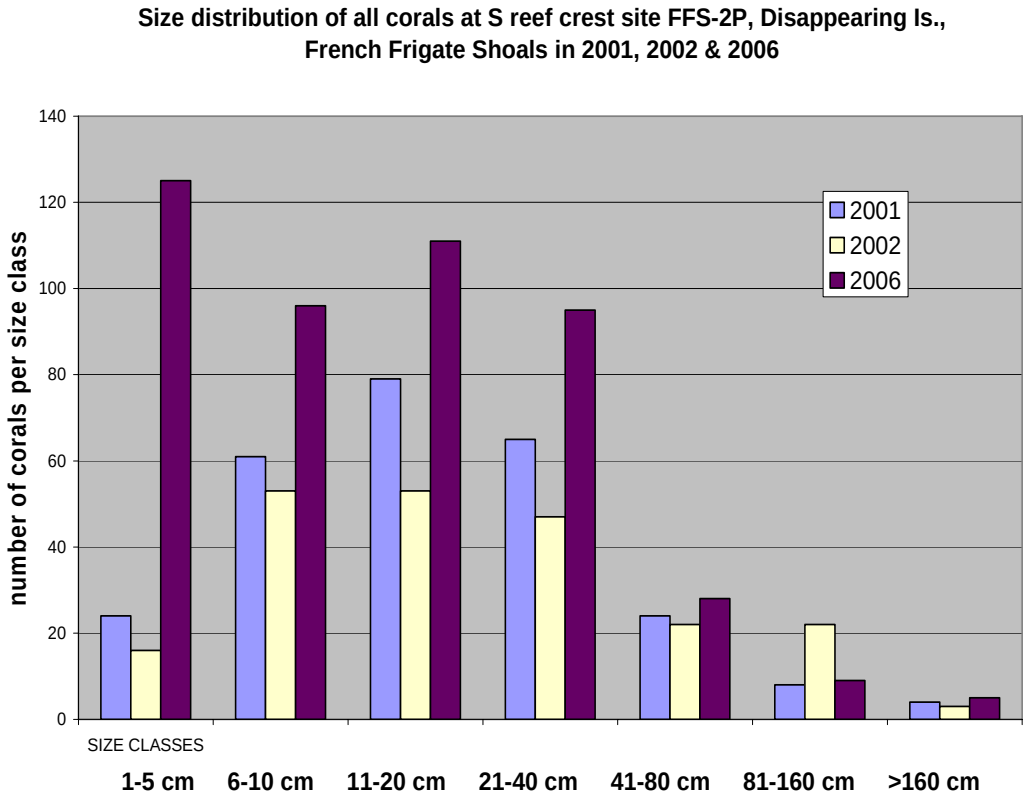

Figure C.3.2.4.2. Size distribution of all corals at French Frigate Shoals site FFS-2P.

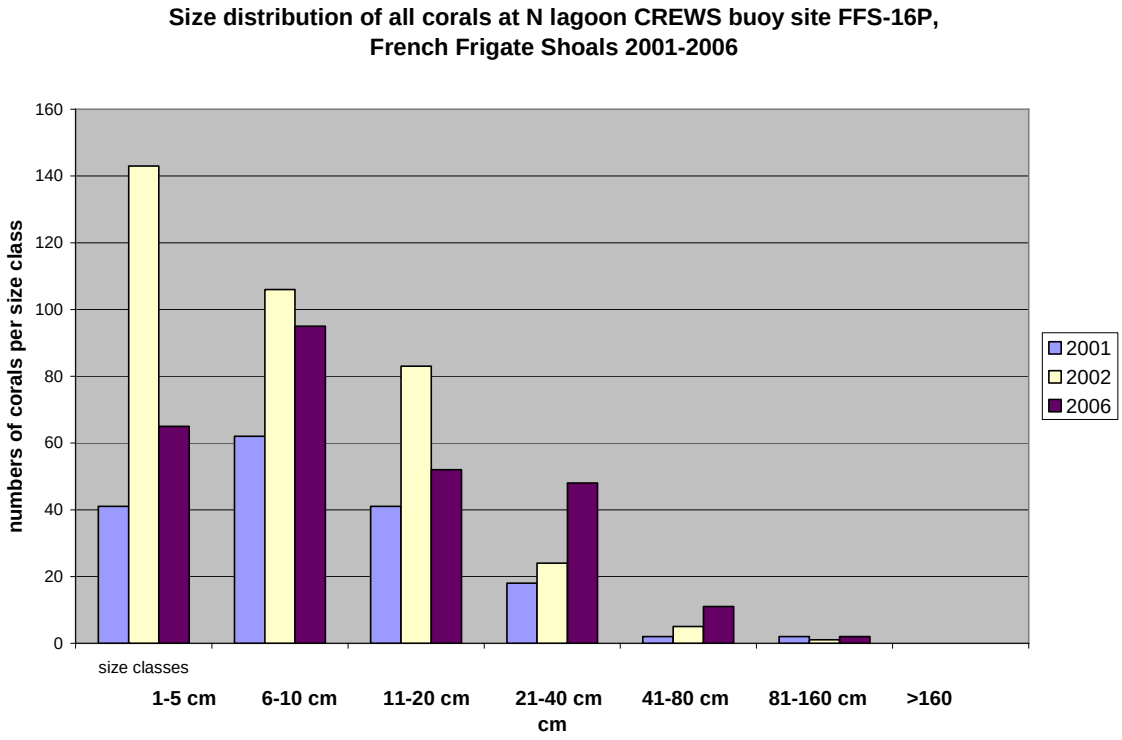

Figure C.3.2.4.3. Size distribution of all corals at French Frigate Shoals site FFS-16P.

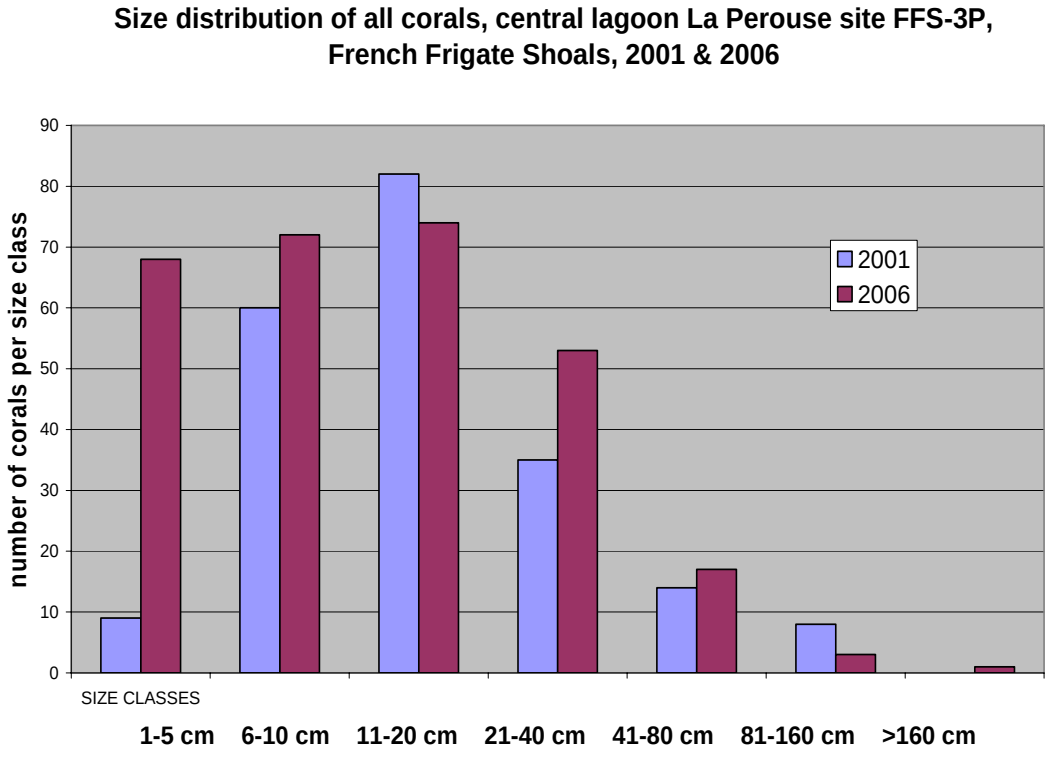

Figure C.3.2.4.4. Size distribution of all corals at French Frigate Shoals site FFS-3P.

C.3.3 Towed-diver Benthic Surveys

A total of 19 towed-diver surveys covering 45.37 kilometers of habitat were completed along the forereef, backreef, and lagoon areas of FFS. Along the forereef, bottom complexity ranged from medium-low to medium in the southern and southeastern reefs and varied from medium to medium-high along the north and northeastern reefs. The backreef was consistently recorded as low to medium-low complexity, and the lagoon was recorded as medium-low to medium bottom complexity, with the exception of La Perouse Pinnacles having a higher overall complexity.

The dominant habitats of the eight forereef surveys were recorded as spur and groove or continuous reef, primarily composed of hard corals. Hard coral cover averaged 22.6%, with higher percentages observed along sections of the northern and southern areas of the shoals, where *Acropora* and *Porites* species covered up to 62.5% of the reef. Macroalgae cover averaged 15.5% of total benthic substrate, with the dominant algae genus being *Halimeda*, while coralline algae accounted for an additional 9.8% of habitat cover.

Four surveys were conducted along the backreef, where pavement reef interspersed between rubble and sand was the dominant habitat. Coral cover averaged 3%, macroalgae cover averaged 13.5%, and coralline algae accounted for 1.7% of benthic cover.

A single survey, moving from forereef to backreef, was made near Shark Island in the northwestern area of FFS. The habitat was very similar to the other forereef surveys conducted, with spur and groove reef being the predominant type observed. Coral cover accounted for 34% of the benthic substrate, while macro and coralline algae covered 7.1 % and 22%, respectively.

Six surveys were conducted on the continuous and patch reefs of the lagoon. Hard coral cover averaged 26.6%, with a substantial increase to 58.1% on the survey conducted around La Perouse Pinnacles where *Porites lobata* was dominant. Macroalgae and coralline algae cover was 7.2% and 7.8%, respectively.

Moderate numbers of sea urchins were recorded during forereef surveys (average 257/5-minute time segment), with slight increases observed in the northeast, whereas sea cucumber numbers were significantly lower (average 6/5-minute time segment), with a few exceptions recorded between the north and the eastern reefs. Sea urchin numbers were comparatively lower on the backreef surveys (average 81/5-minute time segment), while sea cucumbers experienced an increase in comparison with forereef surveys (average 20/5-minute time segment), especially in the southeast. Macroinvertebrate recordings within the lagoon were very low for both sea urchins and sea cucumbers (averaging 2 and less than one, respectively). Finally, a total of 33 crown-of-thorns starfish were recorded in scattered locations on the forereef.

C.4 Fish

C.4.1 REA Fish Surveys

SPC data

A total of 739 fishes of 40 species were counted on stationary point count (SPC) surveys at the 10 FFS sites (74 fishes/dive), 556 of them (75%) were 30 cm or smaller, and 713 of the fishes (96%) were 50 cm or smaller. By far, the most numerous fish species counted in SPCs was *Lutjanus kasmira* (251 individuals counted). Also numerous were *Melichthys niger* (77), *Naso lituratus* (54), *Chlorurus perspicillatus* (48), *Kyphosus spp.* (42), *Monotaxis grandoculus* (39) and *Naso unicornis* (28). Clearly, the large fish seen at FFS were not apex predators.

BLT data

A total of 4117 fish of 95 species were counted at the 10 sites on belt transect (BLT) transects. This reflects a fish density of 0.69 fishes/m^2. The most numerically abundant species were *Chromis vanderbilti* (724 individuals counted), *Ctenochaetus strigosus* (415), and *Thalassoma duperrey* (345). Large schools of goatfishes were encountered at four sites, resulting in high numbers for *Mulloidicthys flavolineatus* (210) and *M. vanicolensis* (151). Other species found in relatively high abundances were: *Lutjanus kasmira* (169 individuals counted), *Kyphosus spp.* (133), *Stegastes fasciolatus* (110), *Chlorurus sordidus* (98), and *Naso lituratus* (98). Interestingly, *Chaetodon trifascialus* (92) and *Acanthurus achilles* (93) were also found in very high abundance. The size frequencies of all fishes counted are presented in Figure C.4.1.1.

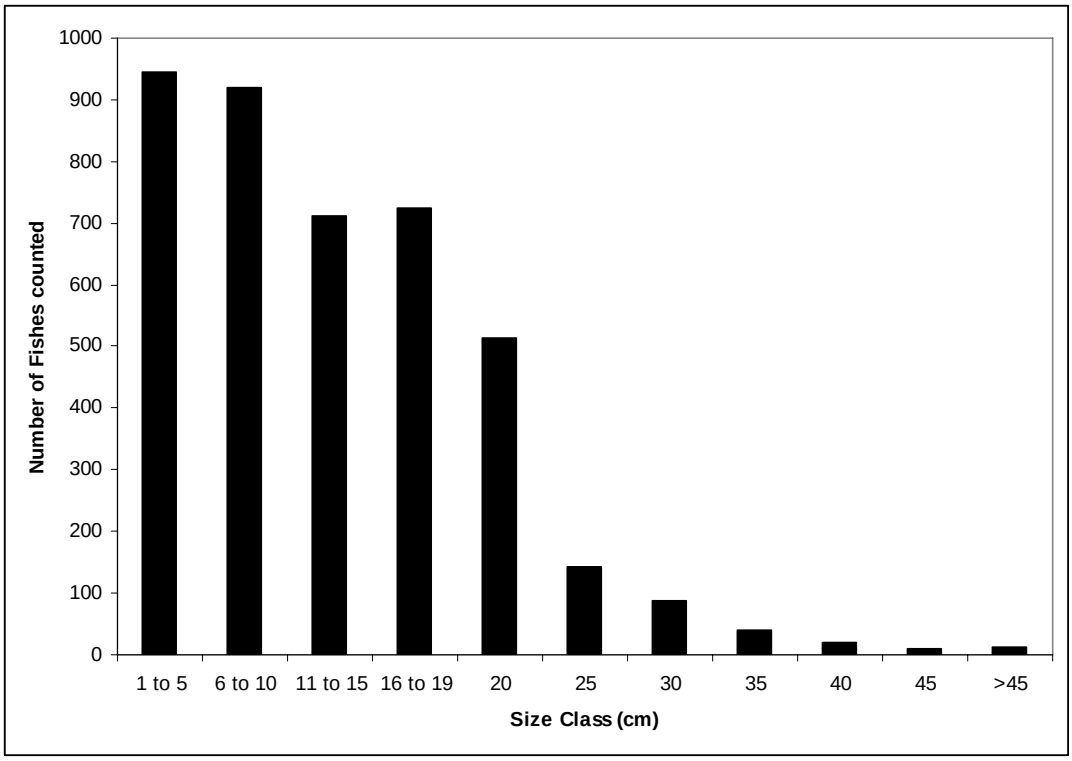

Figure C.4.1.1. Size frequencies of fish at French Frigate Shoals.

Overall observations:

In total, 143 species of fishes were seen at FFS.

C.4.2 Towed-diver Fish Surveys

Table C.4.2.1. HI06_11 Towed-diver Survey Report for French Frigate Shoals.

			Survey length				Mean depth
		N	Min	Max	Median	Sum	Median
French Frigate Shoals	**09/04/2006**	5	2.08	3.18	2.72	12.83	-10.72
	09/05/2006	6	0.69	3.25	2.56	14.40	-9.92
	09/30/2006	5	1.87	2.56	2.47	11.50	-11.53
	10/01/2006	3	2.09	2.26	2.22	6.56	-11.32
	All	19	0.69	3.25	2.34	45.30	-11.02

N = number of surveys conducted.

Survey Length is given in kilometers.

Depth readings are taken at 5-sec intervals during each 50-min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of 17 species of large fishes (>50 cm TL) representing 10 families were observed at FFS during the survey period (09/04/06–09/05/06 and 09/30/06–10/01/06). The mean number of fishes (all species pooled) observed by divers was 0.087 ha^{-1} and the 16 mostly commonly recorded species are shown in Figure C.4.2.1. The green jobfish (*Aprion virescens*) was the most abundant species observed during the quantitative surveys with a mean number of 0.84 fishes observed per hectare. The giant trevally (*Caranx ignobilis*) was the second most abundant fish species encountered during the survey period with a mean numeric density of 0.65 ha^{-1}.

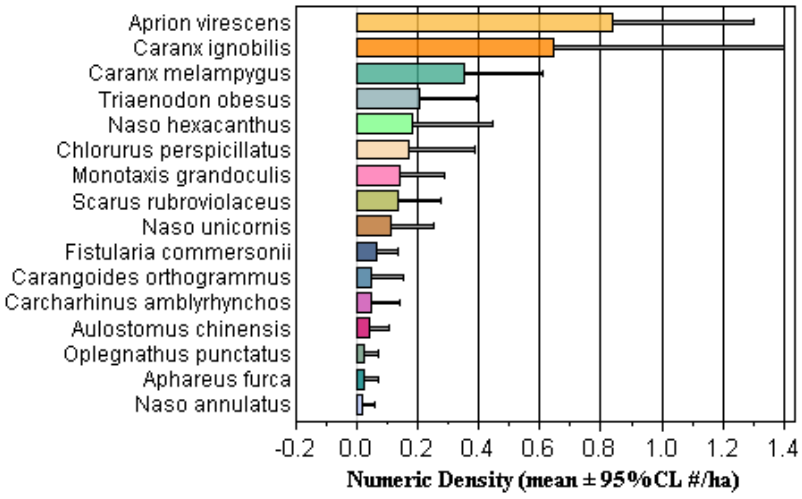

Figure C.4.2.1. The mean numeric density (number of fishes ha^{-1}) of the sixteen most commonly observed fishes at French Frigate Shoals during the survey period.

The grand mean biomass density of fishes observed on the shallow-reefs (<30 m) at FFS during the survey period was 8.81 x 10^{-4} t ha^{-1}. The giant trevally (*Caranx ignobilis*) and whitetip reef shark (*Triaenodon obesus*) accounted for more than 40% of the total mean biomass of large fishes (Fig. C.4.2.2). The giant trevally alone accounted for a quarter of the total large fish (>50 cm TL) biomass with a mean biomass density of 1.01 x 10^{-2} t ha^{-1}. The whitetip reef shark followed behind with a mean biomass density value of 5.78 x 10^{-3} t ha^{-1}.

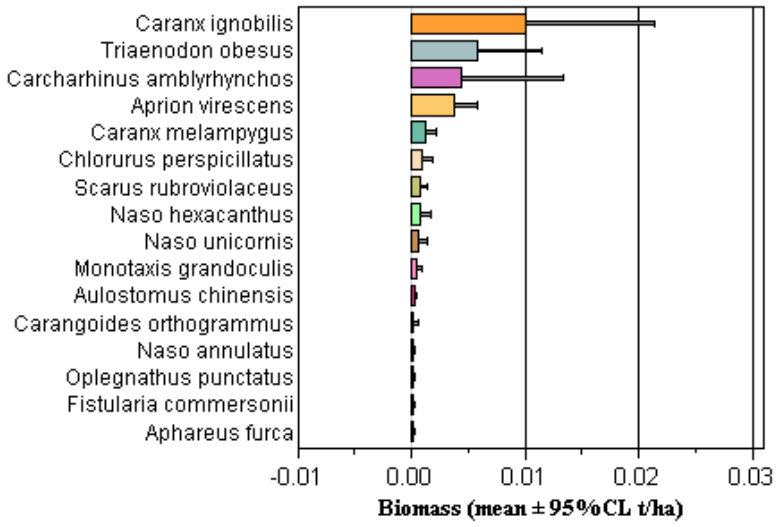

Figure C.4.2.2. The mean biomass (t ha^{-1}) of the sixteen most commonly observed fishes larger than 50 cm (TL) at French Frigate Shoals during the survey period.

C.4.3 Shark Receivers

We recovered, downloaded, and redeployed five receivers stationed at Rapture Reef, Tern Island, Trig Island, East Island, and La Perouse Pinnacles (Table 1). Preliminary analyses revealed that these receivers had detected 26 transmitter-equipped predators since they were last recovered in May 2006.

C.5 Maps

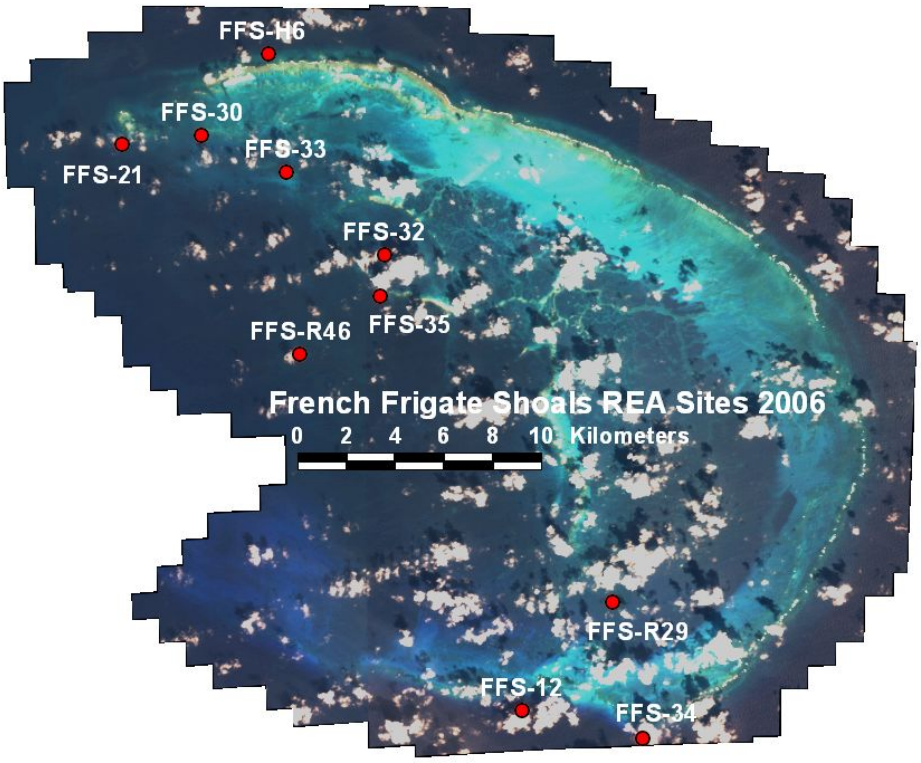

Figure C.5.1. Map showing location of established Rapid Ecological Monitoring (REA) sites at French Frigate Shoals.

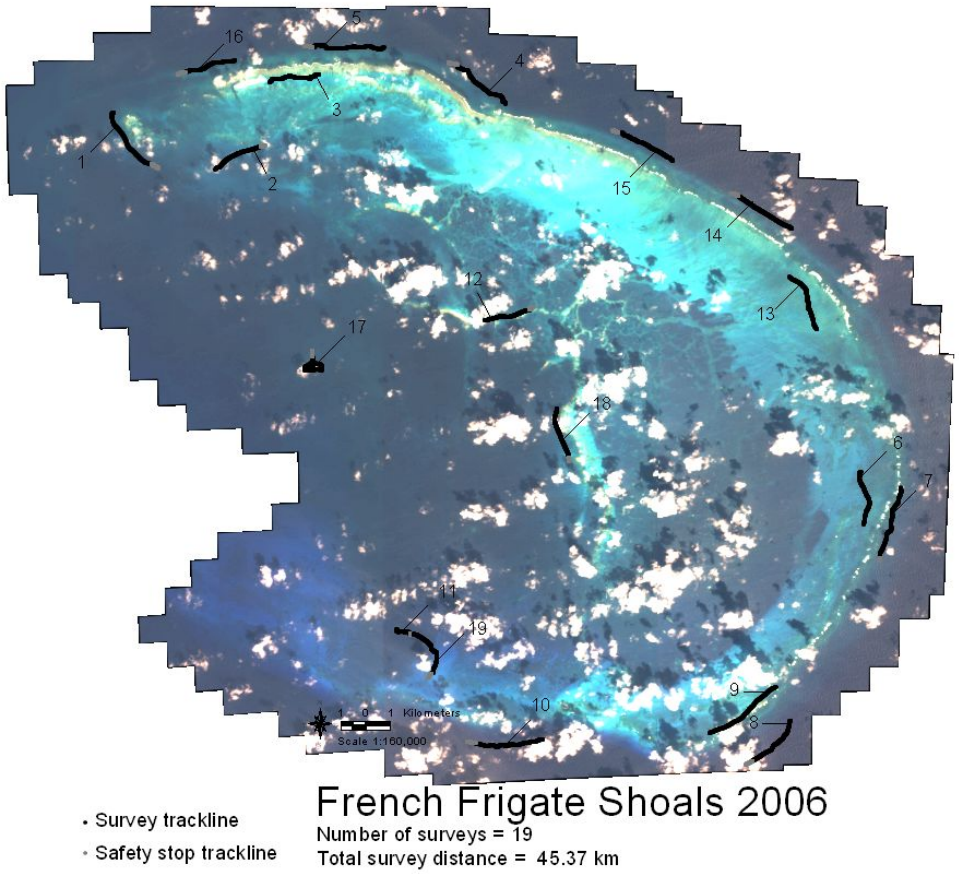

Figure C.5.2. Map showing location of towboard tracks at French Frigate Shoals.

Appendix D: Gardner Pinnacles

D.1. Oceanography and Water Quality

One Subsurface Temperature Recorder (STR) was recovered and a new one deployed in the same location. As a result of an instrument malfunction, the recovered STR has no data.

D.2. Rapid Ecological Assessment (REA) Site Descriptions

No REA surveys conducted.

D.3. Benthic Environment

No REA surveys conducted.

D.3.1. Algae

No algae surveys conducted.

D.3.2. Corals

No coral surveys conducted.

D.3.2.1 Coral populations

No coral surveys conducted.

D.3.2.2 Coral disease

No coral Disease surveys conducted.

D.3.2.4 USFWS permanent coral transects

No USFWS permanent coral transects were visited.

D.3.3 Towed-diver Benthic Surveys

No towed-diver benthic surveys conducted.

D.4 Fish

No REA surveys conducted.

D.4.1 REA Fish Surveys

No fish surveys conducted.

D.4.2 Towed-diver Fish Surveys

No towed-diver fish surveys conducted.

D.4.3 Shark Receivers

We deployed a new underwater receiver on the west side of Gardner Pinnacles at the location given in Table A.5.2.

D.5 Maps

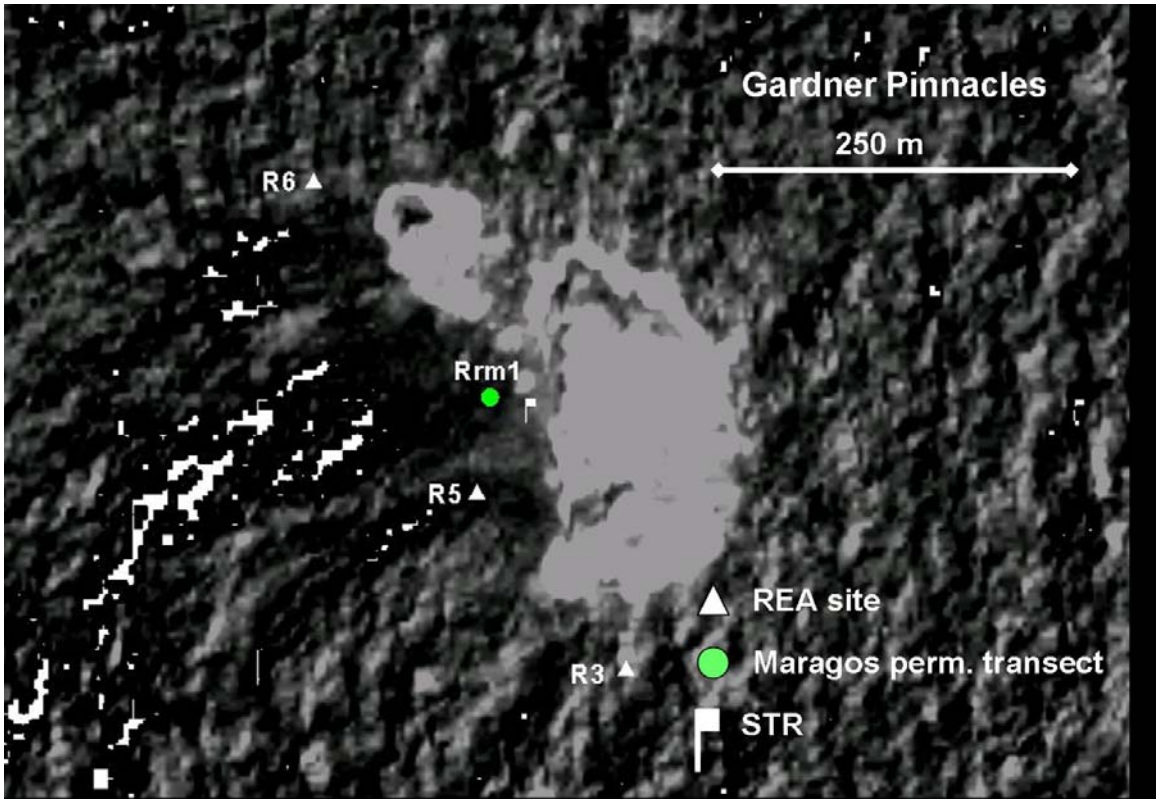

Figure D.5.1. Map showing location of established Rapid Ecological Monitoring (REA) sites at Gardner Pinnacles.

Appendix E: Maro Reef

E.1. Oceanography and Water Quality

One Coral Reef Early Warning System (CREWS) buoy and CREWS buoy anchor was removed and replaced; the newly deployed anchor has been modified to allow for a 6-year deployment, rather than the previous design which only accommodated a 2-year deployment. Three subsurface temperature recorders (STR) were recovered and four were deployed. Three of the four deployments were in the same location as the recovered instruments, while the fourth was a new deployment for Maro. The new deployment location is colocated with a permanent rapid ecological assessment (REA) monitoring site (site 12) to the west side of Maro (Fig. E.1.1.). At this same location, an ecosystem acoustic recorder (EAR) was also deployed.

Eighteen shallow-water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Maro following the 30-m contour. At five of these locations, water sample profiles were performed for a total of 19 water samples measuring chlorophyll and nutrients levels. Water sample profiles were conducted concurrently with CTD casts.

The Coral Reef Ecosystem Division (CRED) first deployed a CREWS buoy at Maro Reef in 2002, and with the recent successful recovery, a 4-year time series of in situ meteorological and oceanographic data now exists. Sea surface temperature is one oceanographic parameter measured by the CREWS buoy and is plotted in Figure E.1.2. Over the 4-year period, sea surface temperature (SST) at Maro is observed to have a maximum of 28.5 °C and a minimum of 19.8 °C and shows predominantly seasonal oscillations with cooler temperatures occurring from February to March and peak warm temperatures occurring from September to October. The two 5-month gaps observed in the temperature data set are because of battery limitations.

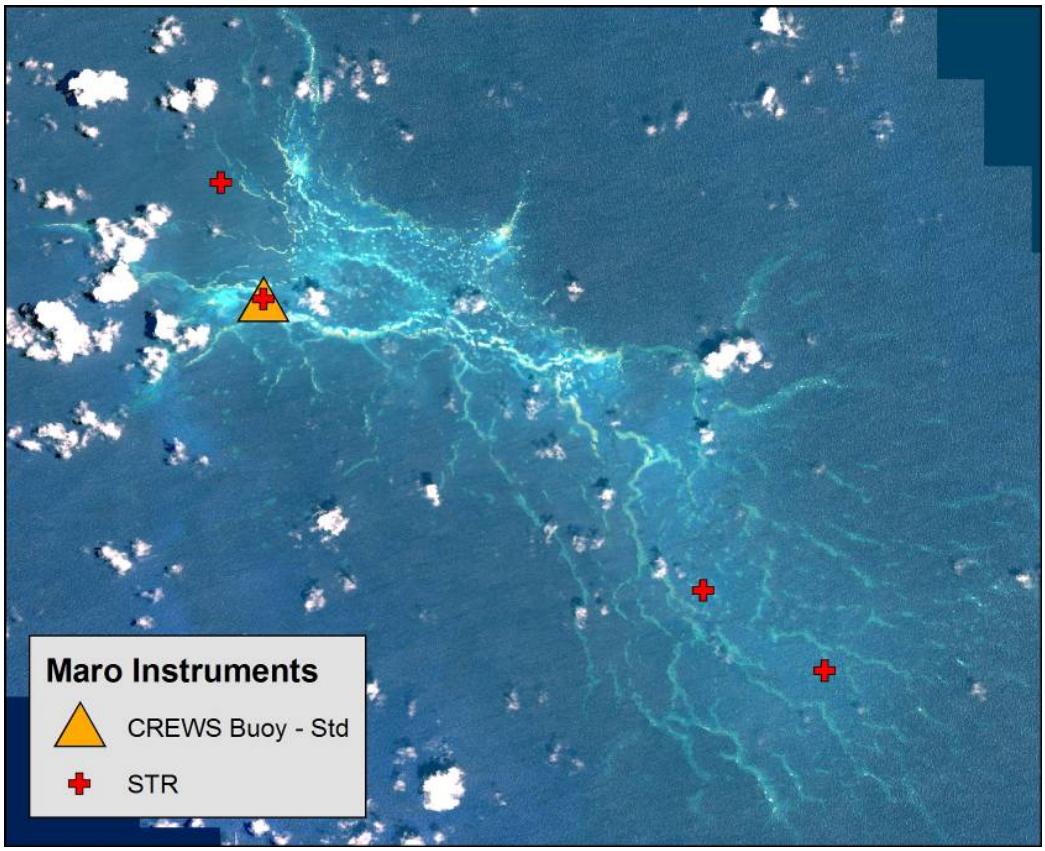

Figure E.1.1. Ikonos image of Maro Reef depicting oceanographic instrumentation deployed during HI0611.

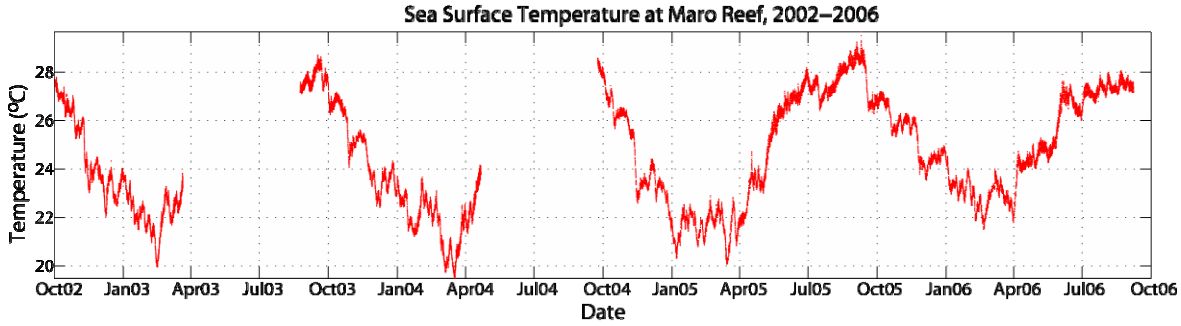

Figure E.1.2. Sea surface temperature measured at Maro Reef from October 2002 to September 2006. Time series shows mostly seasonal oscillations with peak cool temperatures occurring February to March and peak warm temperatures occurring September to October.

E.2. Rapid Ecological Assessment (REA) Site Descriptions

MAR-R12
September 7, 2006

North spur, ocean fringing reef with high topographical relief. Depth range: 13.5–15.5 m. Visibility ~10 m. Used permanent transects (2, 25 m) installed by Greta Aeby in 2005. Compass heading 150°. This high-vertical relief reef site was located adjacent to an expansive sand patch. Extensive *Halimeda opuntia* were prominent, accounting for >35% of the benthic cover. Large individuals of *Bryopsis pennata* that extended up to 10 cm in height and dense clumps of non-geniculate branched coralline red algae were common. Inside photoquadrats, we documented turf algae, *Halimeda opuntia*, *H. velasquezii*, *Bryopsis pennata*, crustose coralline red algae, branched coralline red algae, and cyanophytes. Species of *Neomeris* and *Laurencia* were encountered during the random swim. Moderately low coral (15.6%); dominated by *Porites lobata*. The coral cover was composed of a mixed community of *Porites compressa, P. lobata*, and *Montipora patula*. Montiporids well pigmented, i.e., little bleaching, unlike 2004. Nine scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*P. meandrina*) observed outside belt transects.

Coral disease and health assessment: Nine cases of mild bleaching on *Porites* and *Montipora*, five cases of trematodiasis on *Porites*, seven cases of discoloration and pigmentation response, and two cases of coralline lethal orange disease (CLOD). The site was dominated by smaller surgeons and parrotfish and had low diversity of fish overall. There was a paucity of large predators; all we saw was three ukus.

MAR-R1
September 7, 2006

Ocean fringing reef. Depth range: 8.5–10.5 m; visibility ~17 m. Shallow lee of emergent reef crest behind northwest spur. No permanent transect installed, as site was alternative for R9 (current too high to dive, tried twice) and was not included in State permit. Algae were relatively low in abundance. Turf algae, crustose coralline red algae, *Laurencia galtsoffii*, and *Halimeda velasquezii* were the dominant species/functional groups found in photoquadrats, although *Halimeda discoidea* and cyanophytes were also recorded. *Halimeda opuntia* and additional species of *Laurencia* and cyanophytes were collected during the random swim. This shallow site contained dense coral communities; live coral cover was high (67%), dominated by *Porites lobata, Pocillopora meandrina*, *Montipora patula,* and *M flabellate*; this latter highly fissioned. Montiporids well pigmented, little bleaching, unlike 2004. Twelve scleractinian species enumerated within 50 m^2 belt transects. Three additional scleractinian species (*Acropora cytherea, A. valida*, and *A. humilis*) observed outside belt transects.

Coral disease and health assessment: Many cases (18) of possible trematodiasis with pigmentation response on *P. lobata* + *P. evermanni*/*lutea*, 3 cases of bleaching on *Porites*, 1 case of tissue loss on *Porites,* and 1 case of tube worm infestation on *Pavona*

duerdenei. This was a nice site with numerous jacks around, *Caranx ignobilis* (one tagged), *Caranx melampygus*, *Caranx ferdau*, a large ball of ‘iao was hanging out in shallows, grey reefs cruising the reef edge, a big school of mu, and plenty of uku around. The belt transects were dominated by surgeons and parrotfish. Knifejaws were spotted as well.

MAR-R3
September 7, 2006

Slope of west-northwest spur, sloping from 17.4 to 12.2 meters progressing along transects. Medium high topographical relief, visibility ~25 m. Permanent transects installed. This deep reef site was located next to a steep slope that dropped to 40+ m of water. The current was moderately strong and the algal community diverse. Inside sampled photoquadrats we encountered: turf algae, crustose coralline red algae, *Halimeda opuntia*, *H. velasquezii*, *Dictyosphaeria versluyii*, *Gibsmithia hawaiiensis*, *Lobophora variegata*, *Laurencia galtsoffii*, *L.* sp., *Bryopsis pennata*, and *Caulerpa webbiana*. *Halimeda discoidea* and a cyanophyte were found during the random swim. The coral community was distinguished by high live coral cover (52.3%), dominated by *Porites lobata*, *Montipora patula* and *M flabellata*. Montiporids well pigmented, little bleaching, unlike 2004. *Acropora valida* abundant in patches within and outside belt transects. Eleven anthozoan species (10 scleractinian and *Palythoa*) enumerated within 50 m^2 belt transects. No additional taxa observed outside belt transects. Current picked up to ~1 knot during dive.

Coral disease and health assessment: Many cases (15) of possible trematodiasis with pigmentation response on *P. lobata* + *P. evermanni*/*lutea*, and 1 case of bleaching on *Porites.* There was a large school of *Caranx ignobilis* at this site, and two abnormally large mutants, *Caranx orthogrammus.* A large school of *Acanthurus nigroris* was spawning! On the belt transects, small surgeons were dominant, there were lots of *Thalassoma duperrey*, and overall diversity was mediocre. Divers observed one grey reef and one whitetip reef shark. The slingjaw wrasse at this site were large and seemingly unafraid of divers.

MAR-22
September 8, 2006

South end of western spur, with medium high topography, large areas of rubble. Greta’s permanent transect relocated and resurveyed. Compass heading 130^o (transect 1), 170^o (transect 2), with the start of the second transect ~10 m distant from end of first transect. Depth range: 14.3–18 m; visibility ~10 m. Large mats of *Halimeda opuntia* were common. In the photoquadrats, we recorded turf algae, crustose coralline red algae, *Halimeda opuntia*, *H. velasquezii*, a species of *Laurencia*, *Gibsmithia dotyi*, an encrusting morphology of *Lobophora variegata*, and a cyanophyte. A species of *Nemastoma* and *Gibsmithia hawaiiensis* were found during the random swim. *Ganonema farinosum* was found at a depth of 4.6 meters during our safety stop. Live coral cover was 26.5%; coral community dominated by *Porites compressa*, *Porites lobata* (highly fissioned) and

Montipora capitata. Montiporids not bleached, unlike 2004. Several large (>1m) *Leptastrea* in area. Nine scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Pavona varians*) observed outside belt transects.

Coral disease and health assessment: Six cases of patchy and mild bleaching on *Porites lobata, P. compressa,* and *Montipora patula*; also, one case of tissue loss on *Porites lobata.* In addition, numerous cases of pigmentation responses because of irritations such as contact with algae or algal overgrowth. This site was dominated by small surgeons; there was a lack of large predators in general, although we did see a few *C. galapagensis*. There was a large school of *Melichthys niger* with a couple of very large knifejaws swimming through on occasion.

MAR-6
September 8, 2006

Ocean reticulate reef. Depth range: 7.9–15.9 m. In the algal photoquadrats, we recorded turf algae, *Halimeda opuntia, H. velasquezii,* crustose coralline red algae, a species of *Laurencia,* branched coralline red algae, an encrusting form of *Lobophora variegata, Bryopsis pennata, Dictyosphaeria versluysii,* a species of *Dictyota*, and a species of *Nemastoma*. *Dictyosphaeria cavernosa, Gibsmithia dotyi*, and a cyanophyte were encountered during the random swim. *Halimeda* beds accounted for 14.7 of benthic cover, and turf algae on rubble and dead coral surfaces for 33.3% of the benthos. Live coral cover was 28.4%. Dominated by *Porites compressa*, highly fissioned *P. lobata,* and encrusting *Montipora capitata* and *M. patula*. Montiporids not bleached, unlike 2004. Six scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Fungia scutaria*) observed outside belt transects.

Coral disease and health assessment: One case of patchy and mild bleaching on *Porites lobata,* nine cases of trematodiasis on *Porites* spp., and one case of compromised health condition as a result of predation on *Porites lobata*. Additionally, numerous cases of pigmentation responses on Porites, triggered most likely because of allopathic interaction with algae. This site had scads of *Stegastes fasciolatus, Ctenochaetus strigosus*, and *T. duperrey*. It was not particularly diverse. There were a few uku and a 50-cm omilu and one big ignobilis cruised through. None of these were encountered on transects. The stationary point count (SPC) diver mainly counted parrotfish (*S. dubius* and *C. perspicillatus*).

MAR-8
September 8, 2006

Northerly section of western spur. Medium high topography, including tops, sides, and area in between pinnacles. Greta's permanent transect relocated and resurveyed. Elevated turbidity; visibility ~10 m; depth range: 2.7–7.0 m. In our photoquadrats, we found turf algae, *Halimeda opuntia, H. velasquezii,* crustose coralline red algae, a species of *Laurencia,* branched coralline red algae, an encrusting form of *Lobophora variegata, Bryopsis pennata, Laurencia galtsoffii,* and a species of

Kallymenia. *Gibsmitha dotyi* was collected during the random swim. This shallow site was dominated by coral, especially *Porites lobata* and *P. evermannii*. High topographic complexity; and pinnacles primarily composed of *Porites* compressa mounds, separated by sand/rubble/*Halimeda* channels. *Porites compressa* mounds had inclusions of *Pocillopora*, *Cyphastrea*, and *Pavona*. *Porites lobata*, *Montipora capitata*, and *Montipora patula* were typically located toward bases of mounds. Eleven scleractinian species enumerated within 50 m^2 belt transects. No additional taxa observed outside belt transects.

Coral disease and health assessment: Lower incidence of disease compared to the two prior survey sites. Two cases of bleaching and two cases of tramatodiasis on *Porites* spp. Additionally, numerous cases of pigmentation responses on *Porites*, triggered most likely because of allopathic interaction with algae. This site was characterized by an abundance of juvenile parrotfish, and there were very large abundances of *Acanthurus triostegus* in big roving schools. On the belt transects we saw lots of S*tegastes fasciolatus* again, lots of *C. strigosus, T. duperrey, and A. triostegus.* The SPC diver did not see much. During the REA period we saw a couple of omilus and good sized ignobilis, but overall mediocre diversity and fairly low abundances, except *A. triostegus.*

MAR-R5
September 9, 2006

Southeast; spur, medium topographic relief, strong surge. Shallow reef areas were interspersed with broad sand channels. Depth range: 5.2–8.8 m. New permanent transects installed; compass heading 315^o (transect 1), 270^o (transect 2), with T1 and T2 separated by ~10 m of rubble. Turf algae on rubble and dead coral surfaces accounted for 22% of benthic cover. Turf algae, crustose coralline red algae, *Halimeda velasquezii*, and *H. opuntia* were common in photoquadrats. A species of *Laurencia*, branched coralline red algae, *Dictyosphaeria versluysii*, *D. cavernosa*, *Bryopsis pennata*, and a species of *Martensia* were also found. A cyanophyte was recorded during the random swim. Live coral cover was 29.4%, dominated by highly fissioned *Porites lobata, P. compressa*, and *Montipora capitata*. Montiporids not bleached, unlike 2004. Seven scleractinian species enumerated within 50 m^2 belt transects. Three additional anthozoan species (*Montipora patula*, *Porites brighami*, and *Palythoa* sp.) observed in larger area outside belt transects.

Coral disease and health assessment: Eight cases of bleaching on *Porites lobata* and *Montipora patula*, three cases of trematodiasis on *Porites lobata*, one case of cyano-bacterial overgrowth on *Porites lobata*, and one case of coralline lethal orange disease. Additionally, numerous cases (30) of pigmentation responses on *Porties lobata* and *P. compressa*, generally associated with algal overgrowth. This site was dominated by damsels, especially *Chromis ovalis, Abudefduf abdominalis*, and *Stegastes fasciolatus*. Parrotfish and surgeons were fairly abundant, with lots of juvenile parrotfish and lots of *Ctenochaetus strigosus*. SPC diver saw one large uku and two large *Acanthurus blochii*. Unusual sightings: two morwongs.

MAR-31
September 9, 2006

Southeast; sloping side (~30^{o}) of southerly end of south spur; moderate topographic relief. Depth range: 11–15.5 m; visibility ~ 10 m. This site (not previously assessed by CRED or *Rapture*) was chosen as an alternative to both MAR-R6 and MAR-R8, which were too rough to dive. No permanent transects installed, as site not included in State permit. This steep reef slope contained *Halimeda opuntia which* accounted for 28% of benthic cover and turf algae on rubble and dead coral surfaces for 36% of the benthos. Turf algae, crustose coralline red algae, *Halimeda opuntia, H. velasquezii, Gibsmithia dotyi,* an encrusting form of *Lobophora variegata,* a crustose form of *Codium,* and a species of *Peyssonnelia* were recorded in the photoquadrats. *Dictyosphaeria versluysii,* and species of *Laurencia, Neomeris,* and *Dictyota* were found during the random swim. Coral cover was low (8.8%). Abundant rubble with mixed community of highly fissioned *Porites compressa* and *P. lobata*. Pinnacles constructed of *P. compressa* in deeper water outside belt transects. Eight scleractinian species enumerated within 50 m^2 belt transects. Four additional scleractinian species (*Montipora capitata, M. patula, Pavona maldivensis, Psammocora stellata*) observed in larger area outside belt transects.

Coral disease and health assessment: Four cases of bleaching on *Porites lobata*, and *Montipora patula*. Additionally, numerous cases (11) of pigmentation responses on *Porites*, triggered most likely because of allopathic interactions with algae. There was lots going on here, lots of parrotfish, a school of *Sphyraena helleri* went through, saw some *Caranx ignobilis, Aprion virescens,* and large numbers of surgeons and damsels, particularly *Abudefduf abdominalis* and *Chromis ovalis.*

MAR-32
September 9, 2006

Sloping side (~30^{o}) of mid section of south spur; moderate topographic relief; Ocean reticulate reef. Depth range: 11–14.9 m; visibility ~ 10 m. This site (not previously assessed by CRED or *Rapture*) was also chosen as an alternative to both MAR-R6 and MAR-R8, which were too rough to dive. No permanent transects installed, as site not included in State permit. This site was characterized by a steep reef slope site that contained huge expanses of the calicified, sand-producing alga *Halimeda opuntia*. Within photoquadrats, turf algae, an encrusting form of *Lobophora variegata*, crustose coralline red algae, and *Halimeda opuntia* were most common, although *Halimeda velasquezii, Dictyosphaeria versluysii*, a species of *Dictyota*, branched coralline red algae, and a cyanophyte were also recorded. A large patch of a species of *Sporochnus* was encountered at the end of the second transect line between 15 and 20 meters depth. Rubble-*Halimeda*-turf field dotted with *Porites lobata* and *P. compressa*. Other corals present included *Montipora* spp, *Pavona duerdeni, Psammocora stellata,* and *Cyphastrea ocellina*. Live coral cover was 18.6%. This site was highly similar to site MAR-31: abundant rubble with mixed community of highly fissioned *Porites compressa* and *P. lobata*. Abundant *Halimeda*. Pinnacles constructed of *P. compressa* in deeper water

outside belt transects. Ten scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan taxa observed in larger area outside belt transects.

Coral disease and health assessment: Three cases of trematodiasis on *Porites* spp., additionally, numerous (23) cases of pigmentation responses were noted on *Porites* spp., triggered most likely because of allopathic interaction with algae. This site was dominated by parrotfish, followed by surgeons (especially *Ctenochaetus strigosus*) and damsels. SPC diver enjoyed the experience of 23 *Caranx melampygus* circling him (2 of them rather angry) on the first rep, only saw 4 *Aprion virescens* during dive, and saw absolutely nothing on the last rep. We did see one white-tip reef shark in a crevice with three lobsters.

E.3. Benthic Environment

E.3.1. Algae

Quantitative algal surveys were conducted at nine sites located primarily on the western side of the reef along a north to south axis. Two important sand producing species found throughout all the sites sampled in Maro Reef were *Halimeda velasquezii* and *Halimeda opuntia* (Table E.3.1.1). A large population of *H. velasquezii* were found to be reproductive following the full lunar cycle on September 8, 2006. Species of *Laurencia, Bryopsis pennata,* and an encrusting form of *Lobophora variegata* were also common at many sites sampled. Although still awaiting microscopic confirmation, 21 species of macroalgae were collected along survey lines (Table E.3.1.2): 9 species of green algae, 10 species of red algae, and 2 species of brown algae. Microscopic examination of epiphytes will increase the number of species collected substantially, especially among the red algae.

Table E.3.1.1: Algal genera or functional groups recorded in photoquadrats at Maro Reef. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	MAR-R12	MAR-R1	MAR-R3	MAR-22	MAR-6	MAR-8	MAR-R5	MAR-31	MAR-32
GREEN ALGAE									
Bryopsis	*8.3*	*0.0*	*8.3*	*0.0*	*8.3*	*16.7*	8.3	0.0	0.0
	3.0	**0.0**	**4.0**	**0.0**	**7.0**	**4.0**	4.0	0.0	0.0
Codium	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	**8.3**	**0.0**
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**0.0**
Dictyosphaeria	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	25.0	0.0	8.3
	0.0	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	5.7	0.0	5.0
Halimeda	*100.0*	*91.7*	*83.3*	*91.7*	*83.3*	*83.3*	*91.7*	*100.0*	*91.7*
	2.3	**2.6**	**2.2**	**3.7**	**3.1**	**2.7**	**2.7**	**2.3**	**2.5**
RED ALGAE									
Non-geniculate calcified branched red algae	*50.0*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*	*41.7*	*0.0*	*8.3*
	2.7	**0.0**	**0.0**	**0.0**	**3.5**	**0.0**	**2.6**	**0.0**	**5.0**
crustose coralline algae	*75.0*	*58.3*	*58.3*	*50.0*	*91.7*	*58.3*	*91.7*	*100.0*	*91.7*

	MAR-R12	MAR-R1	MAR-R3	MAR-22	MAR-6	MAR-8	MAR-R5	MAR-31	MAR-32
	3.6	**3.3**	**3.3**	**2.3**	**2.0**	**2.7**	**3.3**	**2.6**	**2.8**
Kallymenia	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**
Gibsmithia	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*
	0.0	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**0.0**
Laurencia	*0.0*	*100.0*	*16.7*	*66.7*	*41.7*	*16.7*	*66.7*	*0.0*	*0.0*
	0.0	**2.8**	**3.5**	**3.6**	**4.2**	**3.0**	**3.9**	**0.0**	**0.0**
Martensia	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**0.0**	**0.0**
Nemastoma	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**6.0**	**0.0**	**0.0**	**0.0**	**0.0**
Peysonnellia	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**
BROWN ALGAE									
Dictyota	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*8.3*
	0.0	**0.0**	**0.0**	**0.0**	**7.0**	**0.0**	**0.0**	**0.0**	**5.0**
Lobophora	*0.0*	*0.0*	*16.7*	*75.0*	*58.3*	*16.7*	*0.0*	*16.7*	*66.7*
	0.0	**0.0**	**2.5**	**3.1**	**3.0**	**1.5**	**0.0**	**3.6**	**3.6**
FUNCTIONAL GROUPS									
turf algae	*100.0*	*100*	*100*	*100.0*	*91.7*	*100.0*	*100.0*	*100.0*	*100.0*
	1.7	**1.0**	**1.1**	**1.0**	**1.1**	**1.2**	**1.0**	**1.3**	**1.2**
Cyanophytes	*8.3*	*16.7*	*0.0*	*41.7*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*
	4.0	**3.5**	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.5**

Table E.3.1.2: Putative algal species found at Maro Reef. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis.

List of putative macroalgal species collected.
(one sample per site)

	MAR-R-12	MAR-R-1	MAR-R-3	MAR-22	MAR-6	MAR-8	MAR-R-5	MAR-31	MAR-32
GREEN ALGAE									
Bryopsis pennata	X		X		X	X	X		
Caulerpa webbiana			X						
Codium sp.								X	
Dictyosphaeria versluysii			X		X		X	X	
Dictyosphaeria cavernosa					X		X		
Halimeda discoidea		X	X						
Halimeda opuntia	X	X	X	X	X	X	X	X	
Halimeda velasquezii	X	X	X	X	X	X	X	X	
Neomeris sp.	X							X	
RED ALGAE									
Non-geniculate calcified branched red algae	X				X	X	X		
Ganonema farinosum				X					
Gibsmithia hawaiiensis			X	X					
Gibsmithia dotyi				X	X	X		X	
Laurencia sp.	X	X	X	X	X	X	X	X	
Laurencia gattsoffii		X	X			X			
Martensia sp.							X		
Kalimenia sp.						X			
Nemastoma sp.				X	X				
Peysonnellia								X	
BROWN ALGAE									
Dictyota spp.								X	
Lobophora variegata			X	X	X	X		X	

E.3.2. Corals

Coral REA surveys were conducted at nine sites. Of these, six were among the nine sites selected by CRED and partners in 2003 for long-term monitoring. Three long-term monitoring sites could not be resurveyed in 2006, however, either due to excessively strong current (MAR-R9, in the northwest) or hazardous surface conditions for maneuvering the dive boat (MAR-R6 and MAR-R8, in the south). Instead, three alternative sites conducive to safer diving were surveyed: MAR-R1 (in the northwest) and MAR-31 and MAR-32 (in the south). Neither MAR-31 nor MAR-32 had been previously assessed during CRED or *Rapture* cruises.

The most recent surveys by CRED at Maro Reef were conducted in September 2004, during which all nine long-term monitoring sites were visited. However, a strong current at site MAR-R9 in 2004 prevented quantitative benthic surveys from being conducted, and only qualitative assessments were possible. Consequently, CRED has no quantitative benthic data for MAR-R9 since 2003. However, site MAR-R9 was surveyed for corals and coral disease by Dr. Evelyn Cox and Dr. Greta Aeby in September 2005 during the Northwestern Hawaiian Islands Ecosystem Reserve cruise, during which Dr. Aeby installed permanent transect (2, 25 m) markers at this site to follow the progression of specific coral diseases. Of all the sites selected for long-term monitoring at Maro Reef, site MAR-R9 is to date the least reliable in terms of its capacity to be resurveyed, because of strong currents.

In 2005, Drs. Cox and Aeby also surveyed six other long-term monitoring sites (MAR-R8, R12, R3, 8, 6, and 22), and Dr. Aeby installed permanent transect (2, 25 m) markers at sites MAR-R12, MAR-8, and MAR-22. These markers were relocated during the present surveys and used as a guide for transect deployment. At the remaining long-term monitoring sites surveyed this year (MAR-R3, MAR-R5, MAR-6), permanent transect markers were installed along the first two transects by members of the REA fish team with the intention of reducing error because of spatial imprecision on future surveys. Global Positioning System site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded after descending, in order to facilitate relocating the markers on future surveys.

E.3.2.1 Coral populations

A total of 2443 colonies belonging to 16 anthozoan taxa were enumerated within belt transects enclosing 450 m^2 benthic substrate (Table E.3.2.1). The most frequently occurring taxa were *Porites compressa, Porites lobata,* and *Montipora capitata*. Four additional taxa not seen within belt transects were observed within the larger survey area surrounding the transect belts (*Acropora humilis, A. valida, Pavona maldivensis,* and *Psammocora stellata*).

Table E.3.2.1. Number of anthozoans enumerated within belt transects at Maro during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Taxon	# of colonies	Percent of total
Acropora cytherea	1	0.0
Acropora valida	0	0.0
Acropora humilis	0	0.0
Montipora capitata	368	**15.1**
Montipora patula	126	5.2
Montipora verilli	0	0.0
Montipora flabellata	17	0.7
Montipora turgescens	0	0.0
Montipora incrassata	0	0.0
Pavona duerdeni	61	2.5
Pavona varians	0	0.0
Cyphastrea ocellina	118	4.8
Leptastrea purpurea	6	0.2
Fungia scutaria	13	0.5
Pocillopora damicornis	16	0.7
Pocillopora eydouxi	0	0.0
Pocillopora ligulata	30	1.2
Pocillopora meandrina	160	6.5
Porites brighami	7	0.3
Porites compressa	973	**39.8**
Porites evermanni	32	1.3
Porites lobata	491	**20.1**
Palythoa sp.	24	1.0
Zoanthus pacifica	0	0.0
Total # colonies	2443	100.0
Area surveyed, m^2	450	

Size class distributions of all corals enumerated within belt transects are shown in Figure E.3.2.1. Of the 2443 colonies whose maximum diameter was visually estimated, 50.1% had a maximum diameter <10 cm, and 10.5% had a maximum diameter >40 cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003– 2005 surveys.

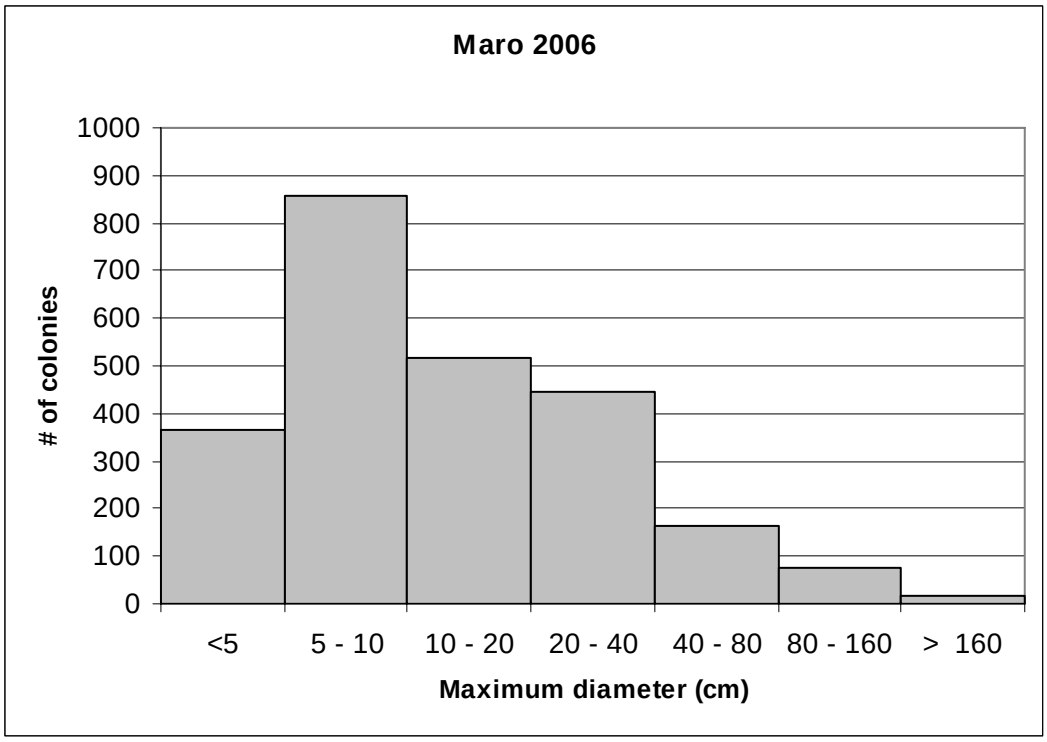

Figure E.3.2.1. Size class distribution of 2443 coral colonies enumerated within belt transects at Maro in 2006.

Substantial bleaching was observed at Maro during September 2004 surveys, particularly in *Montipora capitata* and *M. patula* (27.3% of 286 colonies tallied within belt transects) and pocilloporids (14.5% of 358 colonies tallied within belt transects) (Kenyon and Brainard, in press, Atoll Research Bulletin). Though a coral disease specialist was tasked in 2006 with making specific observations of coral health and disease (see section E.3.2.2), Kenyon's impressions in 2006 were that living colonies of both taxa were well pigmented compared to 2004.

E.3.2.2. Percent benthic cover

Percent benthic cover surveys at Maro Reef were conducted in congruency with the coral population surveys. Point count surveys were conducted along a total of 450 linear meters of coral reef communityat nine different sites at Maro Reef. Point count surveys indicated that mean coral cover was moderately high, 33%, with *Porites lobata* and *P. compressa* accounting for over 72% of all scleractinian coral taxa enumerated along the transect lines. Other coral taxa enumerated along the point intercept transects included *Montipora* spp., *Pocillopora* spp., as well as *Acropora valida.* Turf algae colonizing the carbonate pavement, as well as *Halimeda* also accounted for a substantial portion of the biological benthos (>38%). Table E.3.2.2.1 provides a complete list of the percent cover of the benthic elements enumerated using the point-intercept methodology at Maro Reef. Figure E.3.2.2.1 illustrates the contribution of the different taxa to the total percent live coral cover

Table E.3.2.2.1 Percent cover of the benthic elements at Maro Reef using the point-intercept method during the 2006 REA activities.

Species	Count	% Cover
Acropora valida	5	0.5
Montipora capitata	12	1.3
Montipora flabellata	10	1.1
Montipora patula	36	3.9
Pavona duerdeni	2	0.2
Pocillopora damicornis	3	0.3
Pocillopora ligulata	1	0.1
Pocillopora meandrina	6	0.7
Porites compressa	91	9.9
Porites lobata	133	14.5
Porites evermani/lutea	5	0.5
Leptastrea purpurea	1	0.1
Halimeda	150	16.3
Macro-algae	2	0.2
Branched coralline algae	4	0.4
Pavement/cca	1	0.1
Pavement/turf	31	3.4
Dead/cca	75	8.2
Dead/lobo	4	0.4
Dead/turf	204	22.2
Rubble/ccA	31	3.4
Rubble/turf	92	10.0
Sand	19	2.1
Grand Total	918	

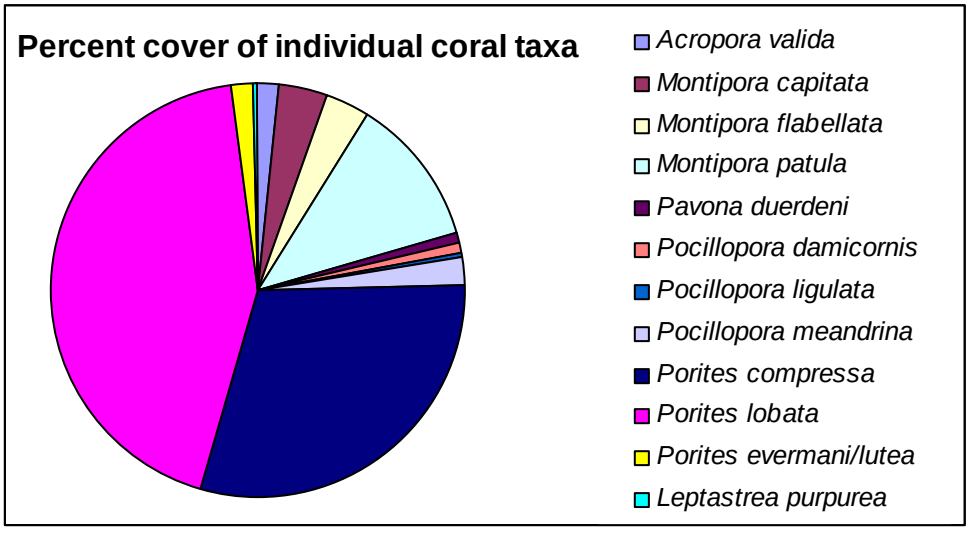

Figure E.3.2.2.1. Percent contribution of the different taxa to the total live coral cover.

E.3.2.3 Coral disease

The coral disease REA surveyed a total of 2700 m^2 at nine different sites and detected four main types of afflictions on scleractinian corals, including bleaching, tissue loss, and trematodiasis, and other parasites. Additionally, two cases of coralline orange lethal disease (CLOD) were noted at MAR-R12 and –R5 (Table E.3.2.3.1) Finally, numerous cases of a compromised health state, involving pigmentation responses, algal growth, discoloration, and intense predation were observed in colonies of *Porites* spp. (Table E.3.2.3.2.). Three tissue samples of pigmentation responses on *Porites lobata* were collected for further histopathological analyses.

Table E.3.2.3.1

Type of disease	Species	Total
Bleaching	*Montipora patula*	7
	Montipora capitata	2
	Porites compressa	8
	Porites evermani/lutea	1
	Porites lobata	16
CLOD	CCA	2
Parasites	*Pavona duerdeni*	1
Tissue loss	*Porites compressa*	1
	Porites lobata	2
Trematodiasis	*Porites compressa*	4
	Porites lobata	18
Grand Total		62

Table E.3.2.3.2

Compromised health condition	**Species**	**Total**
Cyano-bacterial overgrwoth	*Porites lobata*	1
Discoloration other than bleaching (dark)	*Porites lobata*	3
Pigmentation response with algal overgrowth	*Porites compressa*	5
	Porites evermani/lutea	20
	Porites lobata	20
Parrotfish predation	*Porites lobata*	1
Grand Total		50

Figure E.3.2.3.1 illustrates the cumulative number of cases of disease and compromised health state conditions enumerated for all survey areas combined at Maro Reef during the 2006 RAMP cruise. In addition, Figure E.3.2.3.2 illustrates an itemized breakdown of the taxa exhibiting disease and compromised health states. At a future date, these data will be related to coral colony densities and coral cover in order to estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

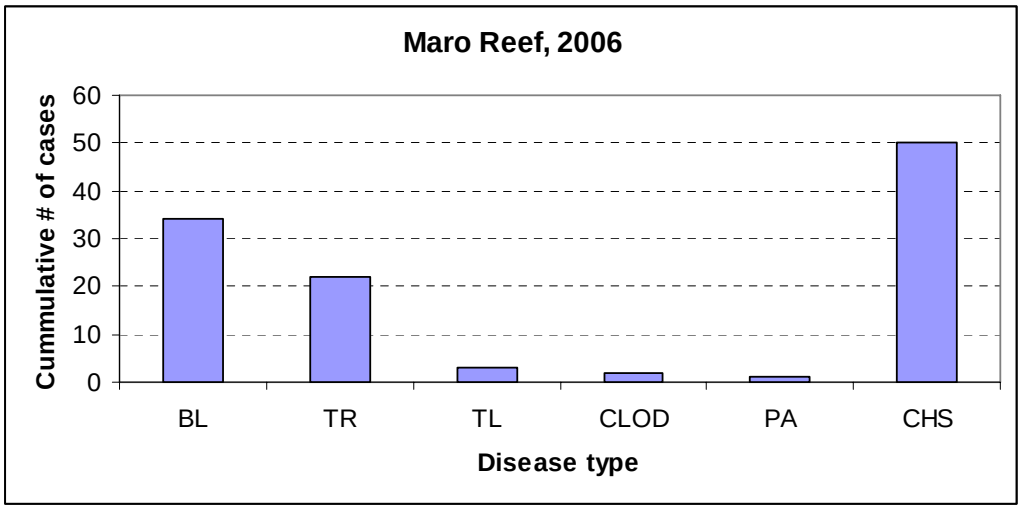

Figure E.3.2.3.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at Maro Reef during the 2006 RAMP cruise. BL: bleaching; TR: tremtodiasis; TL: tissue loss; CLOD: coralline lethal orange disease: PA: other parasites; CHS: compromised health condition.

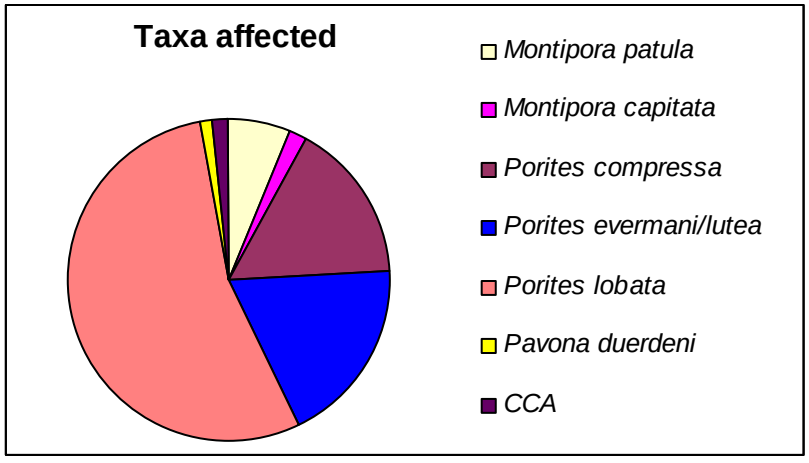

Figure E.3.2.3.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at Maro Reef, 2006. CCA: crustose coralline algae.

E.3.2.4 USFWS permanent coral transects

Three permanent transect sites were established at Maro Reef between September 2001 and September 2002 to track coral and visible macroinvertebrate population changes over time. The September 2006 visits to these sites were the first opportunities to resurvey the intervening 4- to 5-year period. Site MAR-1P is located off the southeastern side of Maro on the south-facing forereef of an ocean patch reef. Site MAR-4P is located on the opposite site of Maro, on the south-facing leeward forereef near the far northwestern tip of Maro on an elongated linear ocean reef. MAR-15P is near the middle of these two extremes in the central shallow protected lagoon 20 m north of the CREWS buoy. All sites were relocated and resurveyed on September 7–9, 2006. The earlier 2001–02 surveys covered 17 m^2 of the southeast site (MAR-1P), 24 m^2 of the northwest site (MAR-4P), and 34 m^2 of the central lagoon site (MAR-15P), while the resurveys covered 50 m^2 for all three sites. All but one or two of the original stakes were relocated at all sites, and Yannis Papastamatiou and Carl Meyer kindly assisted in the relocation of old and the installation of new 3-foot stakes to better mark the ends of all transects. Wave exposure varies considerably among the three, with the southeastern site most exposed, the central site least exposed, and the northwestern site subjected to intermediate exposure but strong tidal and wave driven currents.

Coral population parameters showed mixed trends over the 4- to 5-year period. Generic richness increased from 2-3 genera per transect in 2001 or 2002 to 6-7 genera per site in 2006. The dominant corals at all three transects were the lobe coral, *Porites lobata* and the rose coral, *Pocillopora meandrina.* Other common coral genera were *Pavona* and *Montipora,* the latter completely absent at the southeast site in 2001 (MAR-1P), but common at all three in 2006. The encrusting brain coral *Leptastrea pruinosa* was absent at all three sites in 2001–02 but emerged as a common species only at the northeast site (MAR-4P).

Mean coral diameters decreased at all sites, from 10.9, 29.6 and 36.5 cm in 2001–02 to 10.3, 9.3 and 20.6 in 2006 at sites MAR-1P, MAR-4P, and MAR-15P, respectively. However, coral frequencies (number of corals per m^2) increased at all sites over the same period from 3.8, 4.7 and 6.4 to 5.1, 8.4 and 11.2 corals in 2006 at the same respective sites. Although calculations are not completed, coral cover also appeared to remain the same or increase at all three sites over the period, ranging from 4%, 26%, and 48% in 2001–02 to about 5%, 25%, and 60%, respectively in 2006.

Size distribution of corals changed substantially at all sites. At the CREWS buoy (MAR-15P) where environmental conditions are less favorable to corals, their numbers generally increased at most size classes (Fig. E.3.2.4.1). At the southeast site (MAP-1P), the numbers of small corals decreased substantially in the three smallest size classes since the initial 2001 survey, but showed substantial increases in the four largest size classes over the 5-year period (Fig. E.3.2.4.2). At the far northwest site (MAR-4P), corals were fewer in the smaller size classes but maintained comparable levels in the larger size classes (Fig. E.3.2.4.3). Many larger corals appeared to show signs of fragmentation to smaller sized corals at the two more exposed sites (MAR-1P, MAR-4P), which may help explain the observed shifts in size classes. However, the impact of these trends, also observed at Necker

and French Frigate Shoals may not necessarily be either adverse or favorable to corals, and additional analysis of coral cover and photographic data will better answer this question.

Overall coral populations at the three sites appear to be holding their own, although the data continue to show that MAR-4P is the most favorable for coral development and MAR-15P the least favorable. Less turbidity, strong currents, and plentiful hard surfaces at the former are all supportive of greater coral development, while the combination of greater turbidity and high sediment cover at the CREWS buoy site (MAR-15P) reduces coral recruitment and survival. Site MAR-1P is intermediate in terms of having more solid substrates, but higher turbidity levels appear to favor the *Halimeda* beds that seem to out-compete corals at this site.

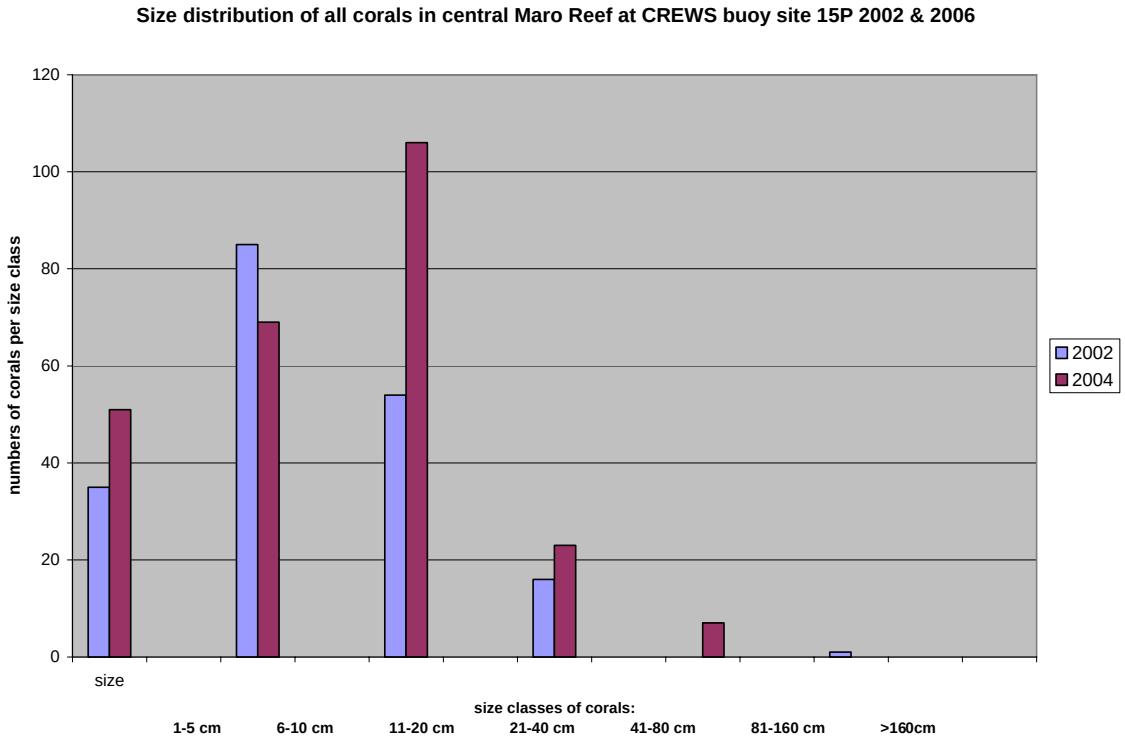

Figure E.3.2.4.1 Size distribution of all corals at Maro Island site MAR-15P. Note: In figure legend, the red box should be labeled "2006" rather than "2004."

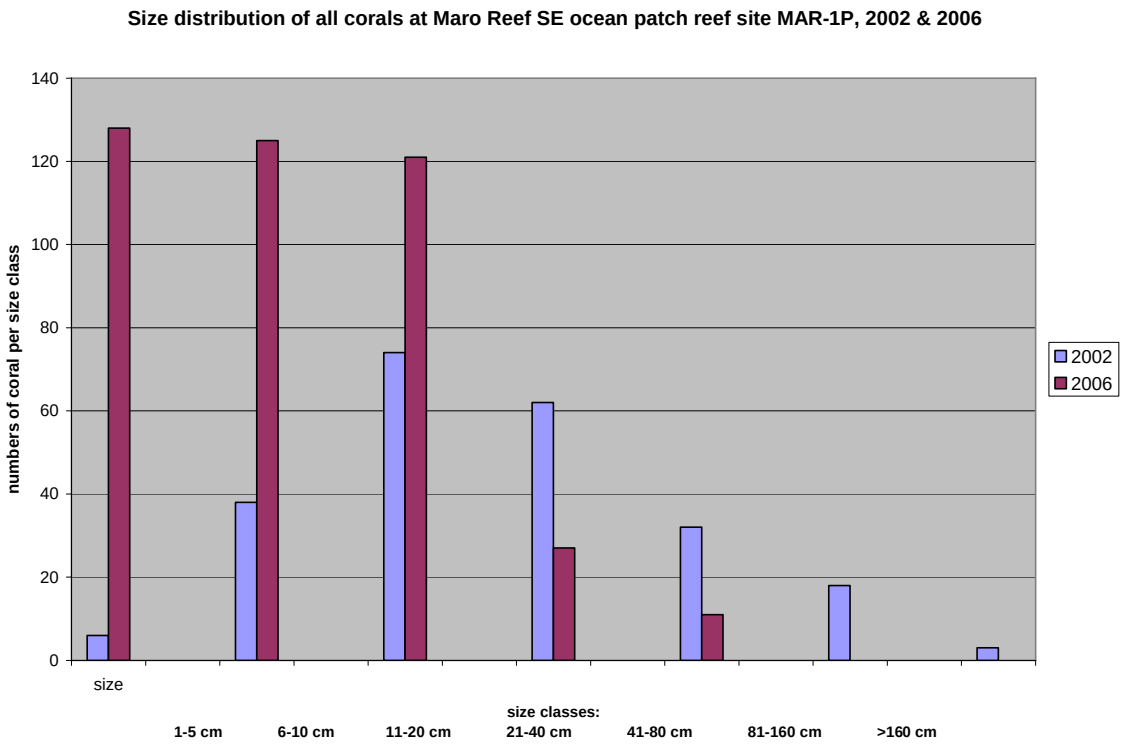

Figure E.3.2.4.2 Size distribution of all corals at Maro Island site MAR-1P.

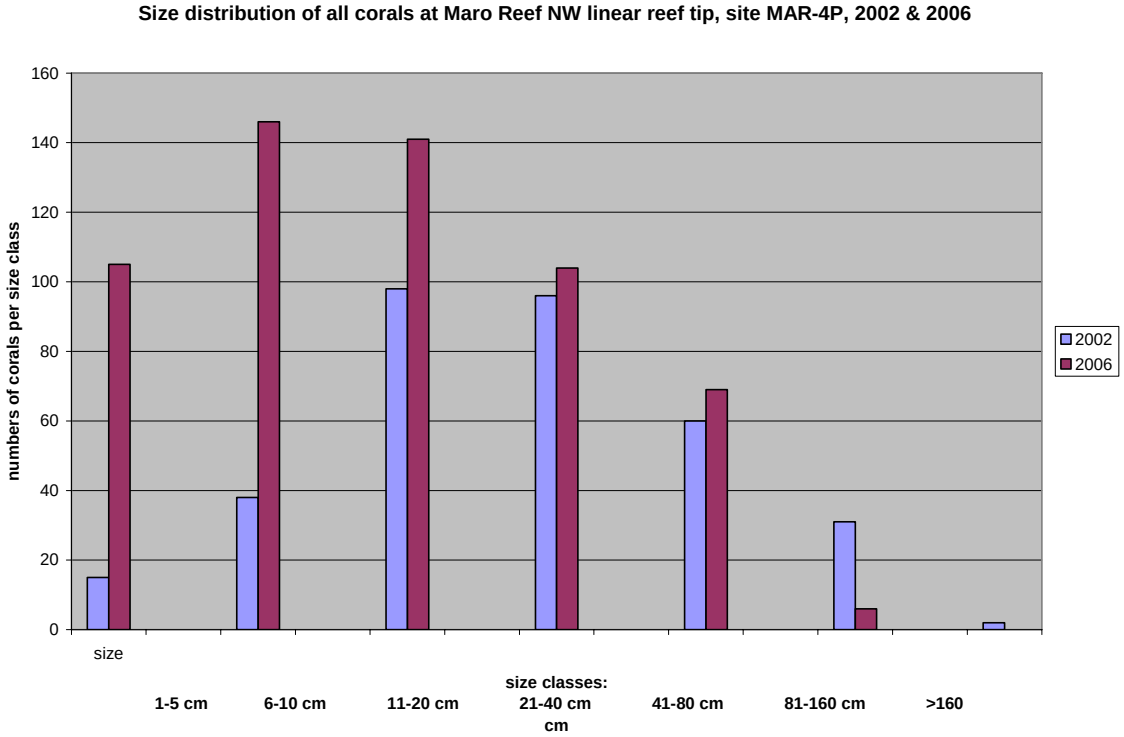

Figure E.3.2.4.3 Size distribution of all corals at Maro Island site MAR-4P.

E.3.3 Towed-diver Benthic Surveys

A variety of different habitats were recorded for Maro Reef over the course of 13 towed-diver surveys. Complexity ranged from low-relief *Halimeda* sand flats and thick *Halimeda* beds in the western and eastern "lagoonal" areas, low-medium to medium complexity rubble and pavement reefs in the southeast region, and medium-high to highly complex areas of spur and groove and continuous reef in the (north)western, central, and east/southeast sections of Maro. The overall average bottom cover was recorded as 13.9% live coral, 14.2% macroalgae, and 8.41% coralline algae for Maro Reef.

Five towboard surveys were completed in the west/northwest, with four occurring on the forereef/ reticulated reef habitats, and one progressing through the western section of the "lagoon." Coral cover averaged 17.8%, with several time segments recording up to 75% coral cover. A large and extensive stand of *Acropora* was noted along the westernmost survey of Maro, with colonies extending from an estimated 35–60+ feet. In addition, a large stand of *Palythoa* was noted towards the end of the tow which corresponded to a recorded increase in current and decrease in visibility. A survey conducted along the western end of the "lagoon" was marked by thick *Halimeda* beds and extensive *Halimeda* sand flats interspersed with patch reefs and shallow water pinnacles.

Three towboard surveys were completed in the central section of Maro, with two occurring along the forereef/reticulated reef habitats, and one progressing along the eastern edge of the "lagoon" and forereef. Coral cover and *Halimeda* were both common, with large beds and patches recorded along the survey of the eastern "lagoon."

Five towboard surveys were completed among the continuous and reticulated reefs in the southeastern region of Maro. This region was characterized as having a relatively equal distribution of hard corals (17.2%), macroalgaes (14.4%), and coralline algaes (16.0%) with patches of sand often found between or running alongside the reef. The reef was often recorded as pavement with patches of *Porites lobata* and different species of *Montipora* as well as an abundance of *Halimeda*.

Macroinvertebrate counts remained low throughout all towed-diver surveys with one exception. Sea urchin counts spiked slightly along a singular tow in the southeast region; however, the remaining surveys did not record any more than 24 individuals. Sea cucumber numbers remained low, with no more than 10 recorded during any complete survey. Additionally, no crown-of-thorns starfish were recorded during towboard surveys of Maro.

E.4 Fish

E.4.1 REA Fish Surveys

SPC data

A total of 739 fishes of 38 species were seen in SPC surveys at the nine Maro sites (82 fishes/dive), and 722 of the fishes (98%) were 50 cm or smaller. The most numerous fishes counted on SPC surveys were *Sphyraena helleri* (120), *Mulloidichthys flavolineatus* (103), and *Melichthys niger* (95); however, all of these tallies resulted from single observations of a large school at a given site. Other numerous species that were seen more regularly at sites were *Caranx melampygus* (78), *Chlorurus perspicillatus* (65), and *Kyphosus spp.* (48). *Aprion virescens* (28) and *Naso unicornis* (29) were seen at six and five of the sites surveyed, respectively. While Maro Reef was described to us as a "sharky" spot, we only counted two sharks on SPC surveys.

BLT data

A total of 3943 fishes of 60 species were counted at the nine sites on BLT transects. This reflects a fish density of 0.73 fishes/m^2. The most numerically abundant species were *Ctenochaetus strigosus* (518 individuals counted), *Thalassoma duperrey* (413), *Scarus psitticus* (352), and *Acanthurus triostegus* (345). Also highly abundant were *Stegastes fasciolatus* (245 individuals counted), *Chromis vanderbilti* (219), *Chromis ovalis* (194), *Chromis hanui* (170), *Chlorurus sordidus* (148), *Acanthurus nigroris* (110), and *Chlorurus perspicillatus* (96). The size frequencies of all fishes counted are presented in Figure E.4.1.1.

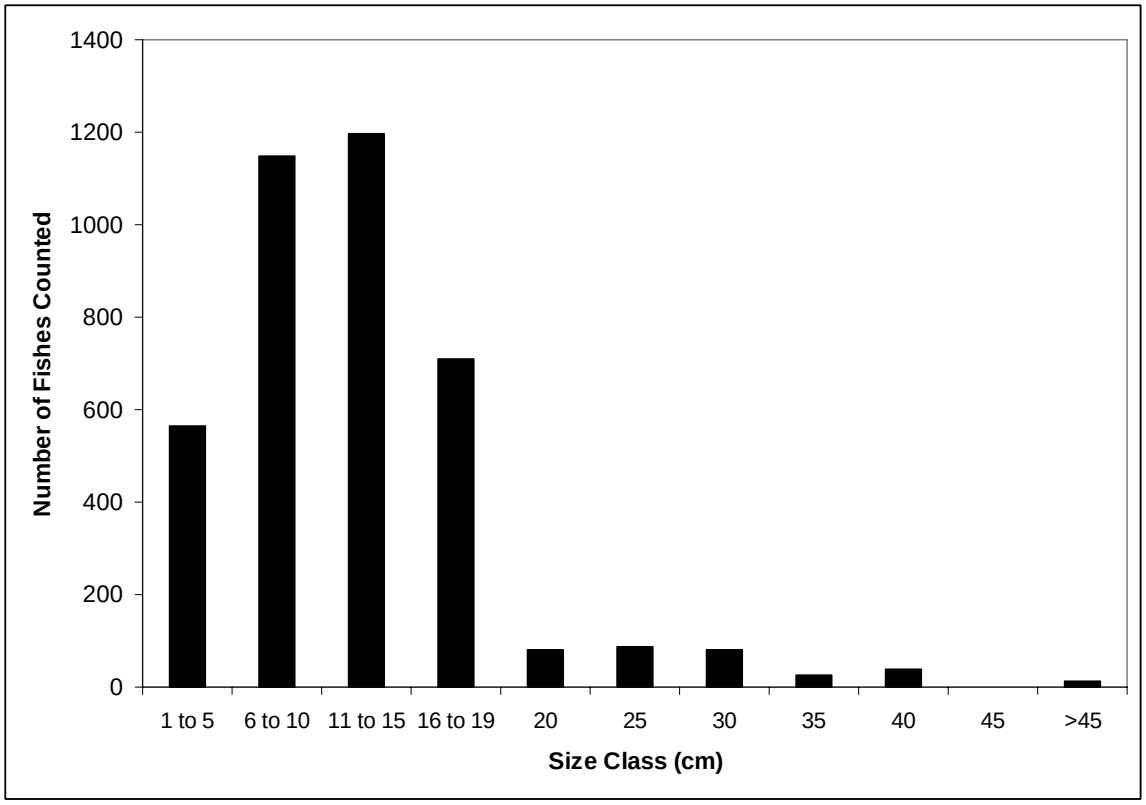

Figure E.4.1.1. Size frequencies of fish at Maro Reef.

Thirteen fishes 50 cm or larger were seen on BLT transects.

Overall observations:

In total, 115 species of fishes were seen by the 3 fish divers on the 9 dives. There were a fair number of predators at this site, with lots of omilu, uku, and ulua. We had lots of issues with current, and the one site where we would have likely counted lots of sharks we were unable to dive because of strong currents.

E.4.2 Towed-diver Fish Surveys

Table E.4.2.1. HI06_11 Towed-Diver Survey Report for Maro Reef.

			Survey Length				Mean Depth
		N	Min	Max	Median	Sum	Median
Maro Reef	**09/07/2006**	5	2.22	2.52	2.37	4.73	-12.19
	09/08/2006	3	1.87	2.45	2.16	4.32	-11.85
	09/09/2006	5	2.39	2.42	2.40	4.80	-7.72
	All	13	1.87	2.52	2.40	13.86	-10.10

N = number of surveys conducted.
Survey Length is given in kilometers.
Depth readings are taken at 5 sec intervals during each 50 min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of 17 species of fishes representing 12 families were observed at Maro Reef during the survey period. The mean number of fishes (> 50 cm TL) was 0.039 ha^{-1} and the 12 mostly commonly recorded species are shown in Figure E.4.2.1. The grey reef shark (*Carcharhinus amblyrhynchos*) were the most commonly observed species during the quantitative surveys with a mean number of 0.201 sharks observed per hectare. Following close behind was the bluespine unicornfish (*Naso unicornis*) with a mean density of 0.196 fishes observed per hectare.

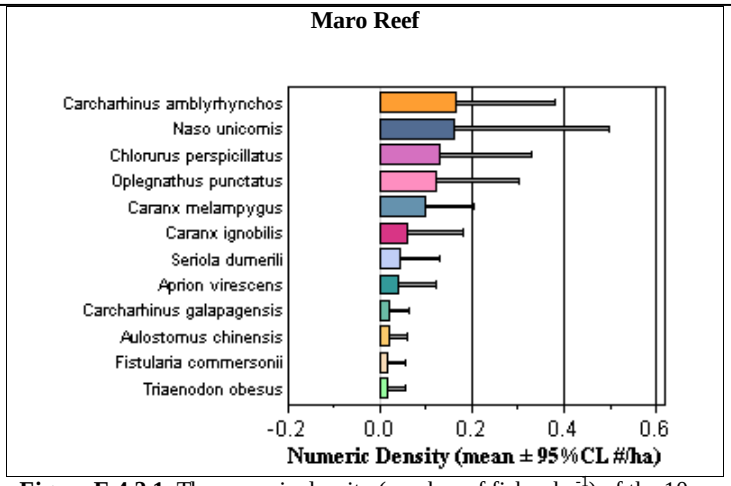

Figure E.4.2.1. The numeric density (number of fishes ha^{-1}) of the 10 most commonly observed fishes at Maro Reef during the survey period.

The grand mean biomass density of fishes observed on the shallow-reefs (<30 m) at Maro Reef during the survey period was 6.3×10^{-4} t ha^{-1}. More than 60% of the total fish biomass at Maro Reef consisted of grey reef sharks (*Carcharhinus amblyrhynchos*) (Fig.

E.4.2.2). Following distantly behind was the giant trevally (*Caranx ignobilis*) with a biomass density of 1.4×10^{-3} t ha^{-1}.

E.4.3 Shark Receivers

We recovered, downloaded, and redeployed one receiver (North Maro), and refurbished the mooring tackle for this unit. We discovered that the second receiver (South Maro) was missing. We replaced this unit with a new receiver and replaced the chain mooring tackle with a sand screw (the old mooring was removed).

E.5 Maps

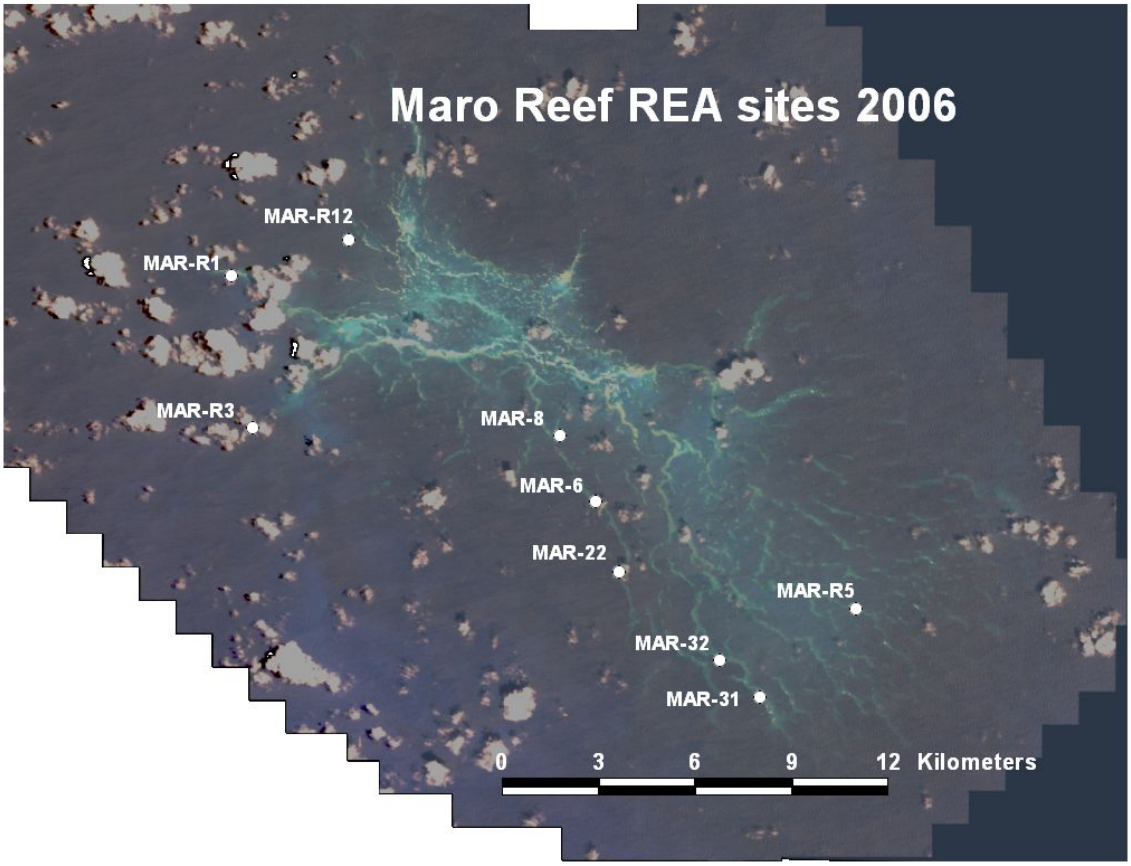

Figure E.5.1. Map showing location of 2006 Rapid Ecological Monitoring (REA) sites at Maro Reef.

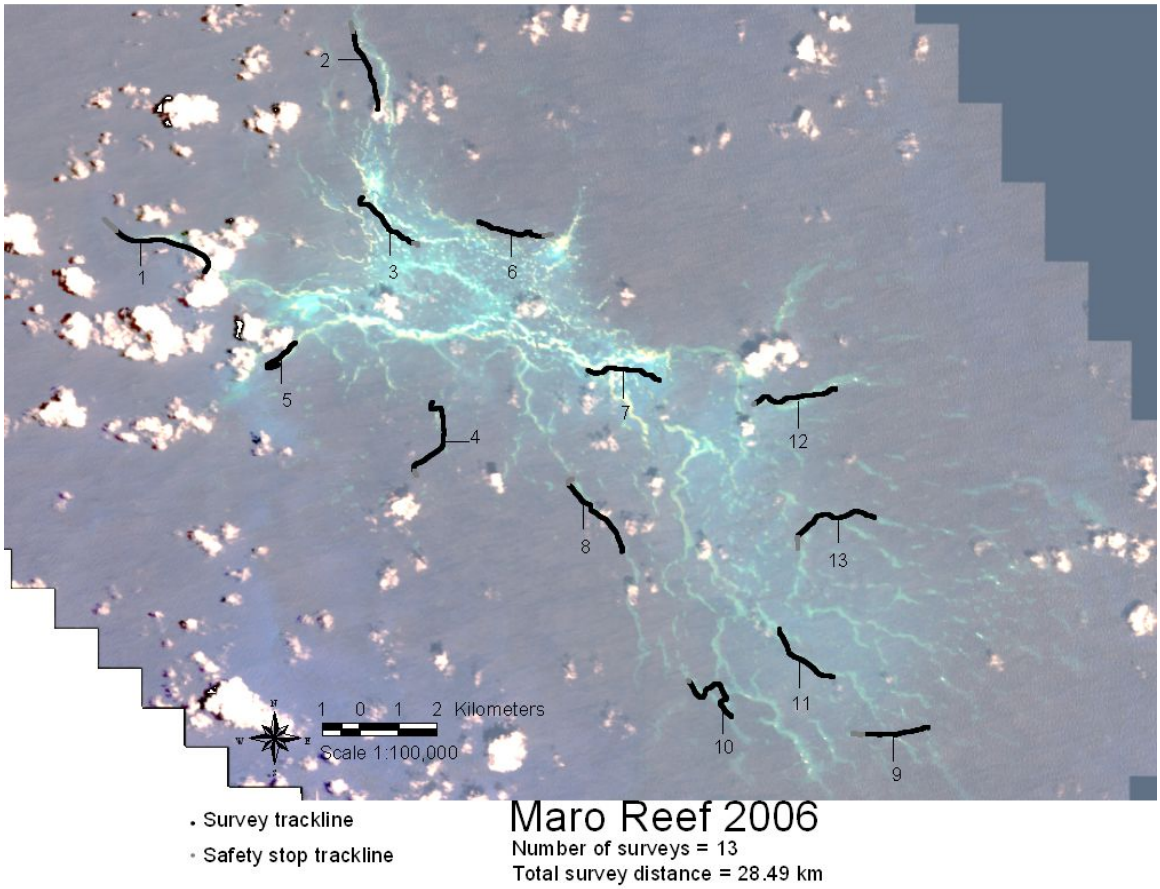

Figure E.5.2. Map showing location of towboard tracks at Maro Reef.

Appendix F: Laysan Island

F.1. Oceanography and Water Quality

One Sea Surface Temperature (SST) buoy and SST anchor was recovered from the west side of Laysan Island (Fig. F.1.1.). A new SST buoy and anchor were deployed in the same location. Three Subsurface Temperature Recorders (STR) were recovered from the northeast, west, and northwest sides of the island; all three were replaced with new instruments programmed for another 2-year deployment.

Six shallow-water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Laysan following the 30-m contour. Because of time constraints, only one water sample profile was performed for a total of three samples which will later be analyzed for chlorophyll and nutrient concentrations.

The SST buoy at Laysan Island was first deployed during the Reef Assessment and Monitoring Program (RAMP) cruise on the *Townsend Cromwell* in 2002, and with the recent buoy recovery, a 4-year time series of in situ sea surface temperature data now exists. Over the 4-year period, SST at Laysan reaches a maximum temperature of 29.5 °C and a minimum of 20.0 °C, while seasonal forcing dominate temperature as cooler temperatures are observed from January to March and peak warm temperatures observed from September to October.

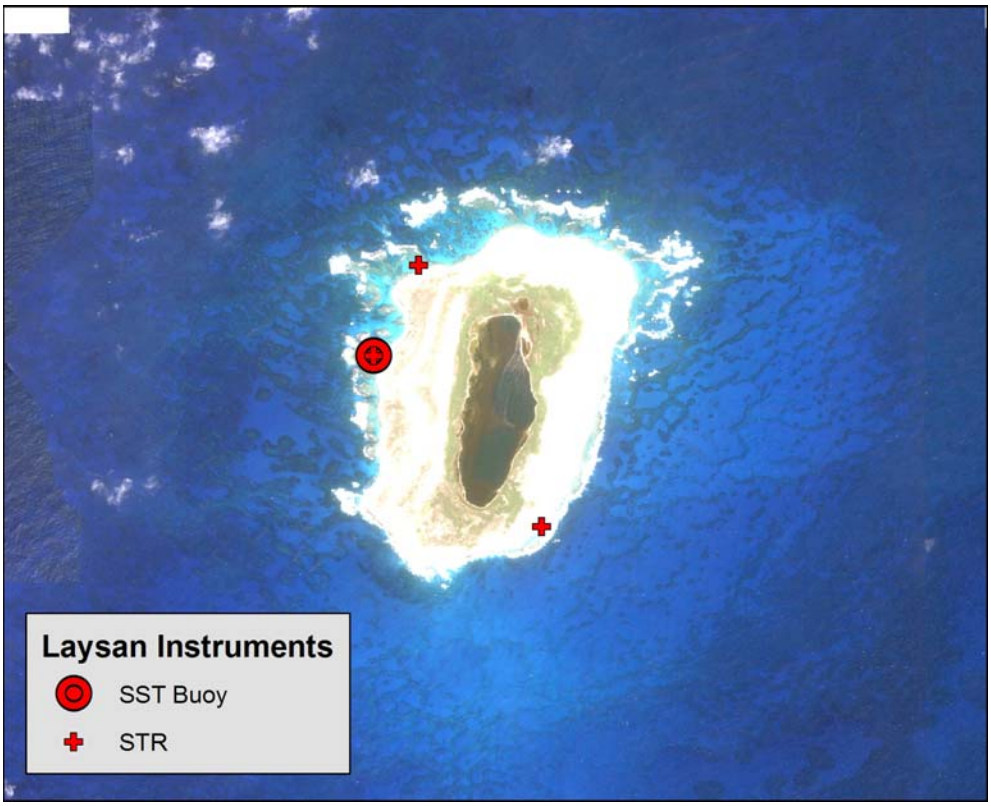

Figure F.1.1. Ikonos satellite image of Laysan Island depicting oceanographic instrumentation deployed during HI0611.

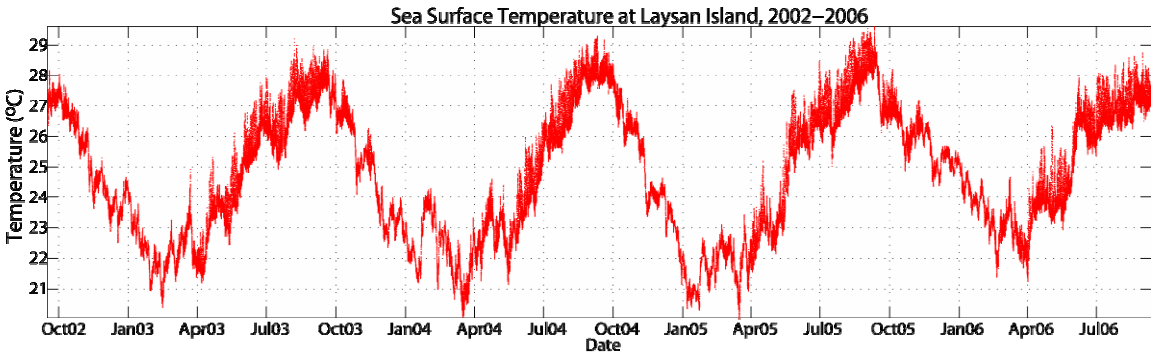

Figure F.1.2. Sea surface temperature measured at Laysan Island from October 2002 to September 2006. Time series shows mostly seasonal oscillations with peak cool temperatures occurring February to March and peak warm temperatures occurring September to October.

F.2. Rapid Ecological Assessment (REA) Site Descriptions

LAY-5
September 10, 2006

North, surgy reef region located at ocean fringing reef. Depth range: 5.8–11.2 m. Visibility ~15 m. New permanent transects installed; compass heading 30°. Coralline algae/turf/*Halimeda*-covered rocky boulders; prominent topographic relief. The algal flora essentially consisted of turf algae, crustose coralline red algae, *Halimeda velasquezii*, encrusting *Lobophora variegata*, and a species of *Laurencia*. During the random swim *Portieria hornemannii*, and species of *Amphiroa* and *Neomeris* were collected. Low coral cover (6.7%); dominated by *Pocillopora* meandering. *Halimeda* accounted for >24% of the benthic cover, and turf algae for 39% of the living benthos. Composed of carbonate shelves and boulders, with many ledges and overhangs. Dominated by *Pocillopora meandrina*. Small encrusting montiporids. Seven scleractinian species enumerated within 50 m^2 belt transects. One additional anthozoan species (Palythoa sp.) observed in larger area outside belt transects.

Coral disease and health assessment: No coral disease detected within the survey area. One case of coralline lethal orange disease observed. This site was dominated by surgeonfishes, damselfishes, and parrotfishes with a large number of *Thalassoma duperrey*. There was a large school of *Acanthurus leucopareius* present at this site. The stationary point count diver saw lots of *Naso unicornis*.

LAY-R12
September 10, 2006

West-northwest. Ocean fringing. Depth range: 7.0–13.6 m. Visibility ~15 m. Coralline algae/turf/*Halimeda*-covered rocky boulders; prominent topographic relief. New permanent transects installed; compass heading 250°. This reef slope was located on the west side of the island adjacent to an extensive sandy area; surge was moderate to high. The algal flora was very diverse. Inside photoquadrats, we recorded turf algae, crustose coralline red algae, non-geniculate branched calcified red algae, *Halimeda velasquezii*, encrusting

Lobophora variegata, Microdictyon setchellianum, cyanophytes, and species of *Peyssonnelia, Coelarthrum, Dictyota, Galaxaura, and Liagora. Gibsmithia hawaiiensis, Portieria hornemannii, Laurencia galtsoffii*, and species of *Amphiroa* and *Martensia* were collected during the random swim. Moderately low coral cover (14.2%), dominated by *Porites lobata*. First transect dominated by highly-fissioned *Porites lobata*; second transect (shallower) dominated by *Pocillopora meandrina*. Sand and rubble at base of carbonate outcrop. Ten scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects. Other corals present within the survey transect included *Montipora patula*. Like the prior site, *Halimeda* and turf algae accounted for over 70% of the benthic cover.

Coral disease and health assessment: Within the survey area (300 m^2) eight cases of bleaching were observed on *Porites* and *Montipora*. Bleaching was focal and mild. Additionally, four cases of trematodiasis on *Porites* and one case of coralline lethal orange disease (CLOD) were noted. Several (<10) cases pigmentation responses were noted on *Porites*; triggered most likely because of irritations and allopathic interaction with algae. This site was dominated by smaller surgeonfishes and also had large numbers of *Stegastes fasciolatus* and *Thalassoma duperrey*. Stationary point counts were again dominated by *Naso unicornis* as well as *Monotaxis grandoculis*. Three very large *Oplegnathus punctatus* were noted by the SPC diver.

LAY-R9
September 10, 2006

South, ocean fringing. Depth range: 6.0–13.7 m. Visibility ~15 m. Coralline algae/turf/*Halimeda*-covered boulders; prominent topographic relief. New permanent transects installed; compass heading 280^o. Large chunks and boulders of carbonate alternating with areas of sand and rubble, located on the south side of the island. Sand channels cut between large rocks. Macroalgae was relatively scarce. Turf algae, *Halimeda velasquezii* (some reproductive!), crustose coralline red algae, *Laurencia* spp., miniscule species of *Padina*, cyanophytes, and a species of *Neomeris* were recorded inside photoquadrats. Gibsmithia *hawaiiensis, Bryopsis pennata, Dasya iridescens, Portieria hornemannii*, and a species of *Galaxaura* were found during the random swim. Moderate coral cover (31%), dominated by highly-fissioned *Porites lobata*, and some colonies of *Montipora patula*. Seven scleractinian species enumerated within 50 m^2 belt transects. Four additional scleractinian taxa (*Montipora patula, Pavona duerdeni, Pocillopora ligulata, Porites evermanni*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey area (300 m^2) 11 cases of bleaching were observed on *Porites lobata* and *Montipora*. On *Porites*, bleaching was focal and mild; on *Montipora*, bleaching was moderate and diffuse. Additionally, five cases of trematodiasis on *Porites* spp. Finally, several (<10) cases pigmentation responses were noted on *Porites*; triggered most likely because of irritations and allopathic interaction with algae. Small surgeons and wrasses dominated at this site, and there were some small goatfish. *Thalassoma duperrey* was the most numerous fish counted. The stationary point count diver

saw lots of surgeonfishes, parrotfishes, *Caranx melampygus*, *Caranx ignobilis*, *Monotaxis grandoculis*, and a variety of large wrasses.

F.3. Benthic Environment

F.3.1. Algae

Quantitative algal surveys were conducted at three sites located on the north, west, and south sides of the fringing reef at Laysan Island (LAY-5, LAY-R-9, LAY-R12). The prominent topographic relief seemed to be composed mainly of crustose coralline algae, turf and rocky boulders covered by *Halimeda.* The algal species, *Portieria hornemannii and Halimeda velasquezii* were present throughout all the sites sampled in Laysan Island. In addition most of the species found in this site are red algae, i.e., *Amphiroa, Coelarthrum, Laurencia Liagora, Galaxaura, and Peysonnellia*. Overall, 4 species of green algae, 12 species of red algae, and 3 of brown algae were collected. In addition microscopic examination of epiphytes will increase the number of species collected substantially, especially among the red algae.

Table F.3.1.1: Algal genera or functional groups recorded in photoquadrats at Laysan Island. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	LAY-5	LAY-R-9	LAY-R-12
GREEN ALGAE			
Halimeda	*100.0*	*66.7*	*100.0*
	2.8	**2.4**	**3.0**
Microdictyon	*0.0*	*0.0*	*58.3*
	0.0	**0.0**	**3.0**
Neomeris	*0.0*	*8.3*	*0.0*
	0.0	**5.0**	**0.0**
RED ALGAE			
Non-geniculate calcified branched red algae	*0.0*	*0.0*	*25.0*
	0.0	**0.0**	**4.7**
Coelarthrum	*0.0*	*0.0*	**8.3**
	0.0	**0.0**	**5.0**
crustose coralline algae	*100.0*	*66.7*	*91.7*
	2.4	**3.5**	**2.9**
Galaxaura	*0.0*	*0.0*	*25.0*
	0.0	**0.0**	**5.0**
Laurencia	*66.7*	*66.7*	*0.0*
	3.4	**2.8**	**0.0**
Liagora	*0.0*	*0.0*	*8.3*
	0.0	**0.0**	**5.0**
Peysonnellia	*0.0*	*0.0*	*8.3*
	0.0	**0.0**	**6.0**

	LAY-5	LAY-R-9	LAY-R-12
BROWN ALGAE			
Dictyota	*0.0*	*0.0*	*25.0*
	0.0	**0.0**	**4.3**
Lobophora	*16.7*	*25.0*	*16.7*
	4.0	**2.0**	**3.5**
Padina	*0.0*	*16.7*	*0.0*
	0.0	**5.0**	**0.0**
FUNCTIONAL GROUPS			
turf algae	*100.0*	*100*	*100*
	1.4	**1.0**	**1.0**
Cyanophytes	*8.3*	*25.0*	*16.7*
	5.0	**5.0**	**6.5**

Table F.3.1.2: Putative algal species found at Laysan Island. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis.

List of putative macroalgal species collected.
(one sample per site)

	LAY-5	LAY-R-9	LAY-R-12
GREEN ALGAE			
Bryopsis pennata		X	
Halimeda velasquezii	X	X	X
Microdictyon setchellianum			X
Neomeris sp.	X	X	
RED ALGAE			
Amansia glomerata	X		
Non-geniculate calcified branched red algae			X
Coelanthrum			X
Dasya iridescens		X	
Galaxaura spp		X	X
Gibsmithia hawaiiensis		X	X
Laurencia sp.	X	X	
Laurencia gattsoffii		X	X
Liagora spp			X
Martensia sp.			X
Peysonnellia			X
Portieria hornemannii	X	X	X
BROWN ALGAE			
Dictyota spp.			X
Lobophora variegata	X	X	X
Padina spp.		X	

F.3.2. Corals

Coral REA surveys were conducted at all three sites that were selected by CRED and partners in 2003 for long-term monitoring. The most recent surveys by CRED or partners at Laysan were conducted in September 2004, during which Site LAY-5 could not be surveyed because of an excessively strong swell, and an alternative site (LAY –R11) was surveyed instead. At all three long-term monitoring sites, permanent transect markers were installed this year along the first two transects by members of the REA fish team with the intention of reducing error because of spatial imprecision on future surveys. GPS site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded after descending, in order to facilitate relocating the markers on future surveys.

F.3.2.1 Coral populations

A total of 426 colonies belonging to 12 anthozoan taxa were enumerated within belt transects enclosing 450 m^2 benthic substrate (Table F.3.2.1). The most frequently occurring taxa were *Porites lobata*, *Pocillopora meandrina,* and *Montipora capitata*. Only one additional taxa not seen within belt transects was observed within the larger survey area surrounding the transect belts (*Pocillopora ligulata*).

Table F.3.2.1. Number of anthozoans enumerated within belt transects at Laysan during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Taxon	# of colonies	Percent of total
Acropora cytherea	0	0.0
Acropora valida	0	0.0
Acropora humilis	0	0.0
Montipora capitata	40	9.4
Montipora patula	7	1.6
Montipora verilli	0	0.0
Montipora flabellata	0	0.0
Montipora turgescens	0	0.0
Montipora incrassata	0	0.0
Pavona duerdeni	16	3.8
Pavona varians	9	2.1
Cyphastrea ocellina	19	4.5
Leptastrea purpurea	1	0.2
Fungia scutaria	0	0.0
Pocillopora damicornis	0	0.0
Pocillopora eydouxi	0	0.0
Pocillopora ligulata	0	0.0
Pocillopora meandrina	74	**17.4**
Porites brighami	16	3.8
Porites compressa	8	1.9
Porites evermanni	1	0.2
Porites lobata	234	**54.9**

Taxon	# of colonies	Percent of total
Psammocora stellata	1	0.2
Palythoa sp.	0	0.0
Zoanthus pacifica	0	0.0
Total # colonies	426	100.0
Area surveyed, m^2	100	

Size class distributions of all corals enumerated within belt transects are shown in Figure F.3.2.1. Of the 426 colonies whose maximum diameter was visually estimated, 44.4% had a maximum diameter <10 cm, and 8.2% had a maximum diameter >40 cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003–2004 surveys.

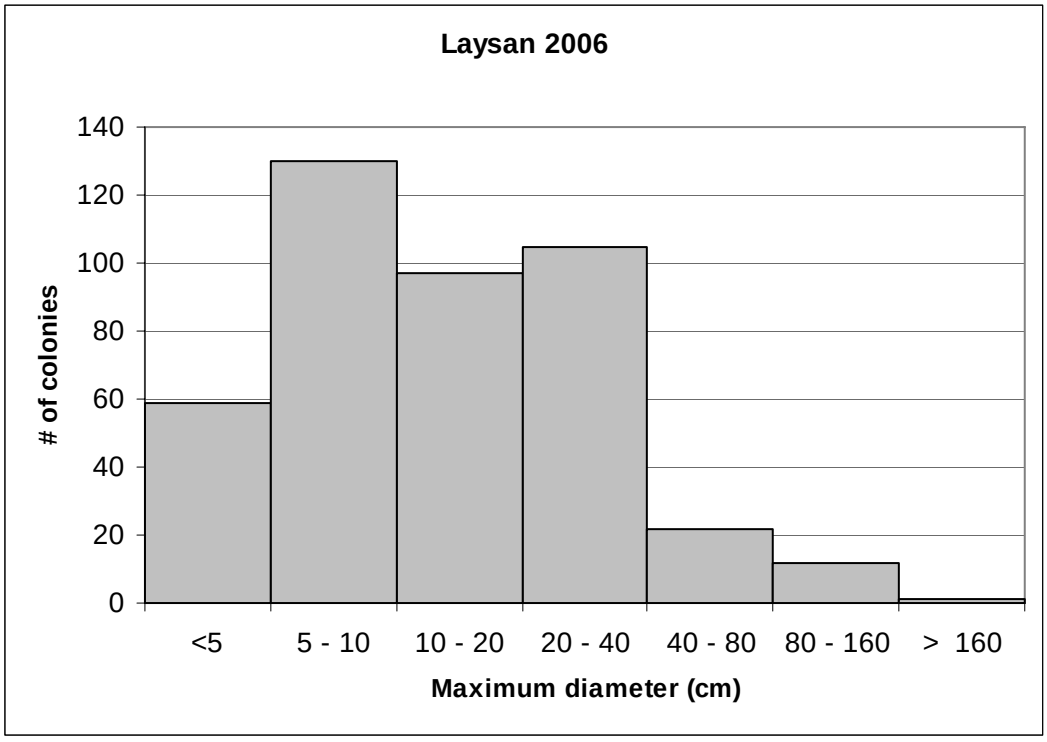

Figure F.3.2.1. Size class distribution of 426 coral colonies enumerated within belt transects at Laysan in 2006.

Substantial bleaching was observed at Laysan during September 2004 surveys, particularly in *Montipora capitata* and *M. patula* (20.7% of 58 colonies tallied within belt transects) (Kenyon and Brainard, in press, Atoll Research Bulletin). Though a coral disease specialist was tasked in 2006 with making specific observations of coral health and disease (see section F.3.2.2), Kenyon's impressions in 2006 were that living colonies of both taxa were well-pigmented compared to 2004.

F.3.2.2. Percent benthic cover

At Laysan Island, point count surveys were conducted along a total of 150 linear meters of coral reef community at three different sites. Point count surveys indicated that mean coral cover was near 18%, with *Porites lobata* alone accounting for over 72% of all scleractinian coral taxa enumerated along the transect lines. Turf algae colonizing the carbonate pavement, as well as *Halimeda* also accounted for a substantial portion of the biological benthos (>58%). Table F.3.2.2.1 provides a complete list of percent cover of the different benthic elements enumerated using the point-intercept methodology at Laysan. Figure F.3.2.2.1 illustrates the contribution of the different scledractinain taxa to the total percent live coral cover

Table F.3.2.2.1 Percent cover of the benthic elements at Laysan Island using the point-intercept method during the 2006 REA activities.

Species	Total	% Cover
Porites lobata	40	13.1
Pocillopora meandrina	7	2.3
Montipora patula	4	1.3
Montipora capitata	2	0.7
Pocillopora ligulata	1	0.3
Cyphastrea ocellina	1	0.3
Halimeda	52	17.0
Macro-algae	10	3.3
Rock/cca	51	16.7
Rock/turf	127	41.5
Coralline algae	1	0.3
Dead/cca	3	1.0
Sand	7	2.3
Grand Total	306	

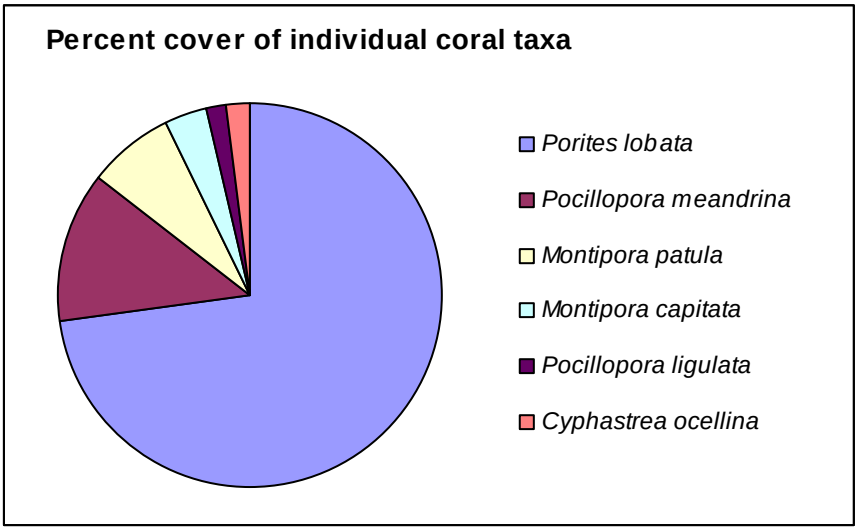

Figure F.3.2.2.1. Percent contribution of the different taxa to the total live coral cover

F.3.2.3 Coral disease

The coral disease REA surveyed a total of 900 m^2 at three different sites and detected two main types of afflictions on scleractinian corals, including bleaching and trematodiasis. Additionally, two cases of coralline orange lethal disease (CLOD) were noted at LAY-5 and LAY-R12 (Table F.3.2.3.1). Compared to Maro Reef, fewer cases (20) of compromised health state, involving pigmentation responses and algal growth on *Porites* spp. were detected at Laysan Island.

Table F.3.2.3.1

Disease/syndrome	Species	Total
Bleaching	*Montipora capitata*	9
	Porites lobata	10
CLOD	Crustose coralline algae	2
Trematodiasis	*Porites compressa*	2
	Porties lobata	8
Grand Total		31

Figure F.3.2.3.1 illustrates the cumulative number of cases of disease conditions enumerated for all survey areas combined at Laysan during the 2006 RAMP cruise. In addition, Figure F.3.2.3.2 illustrates an itemized breakdown of the taxa exhibiting disease and compromised health states. At a future date, these data will be related to coral colony densities and coral cover in order to estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

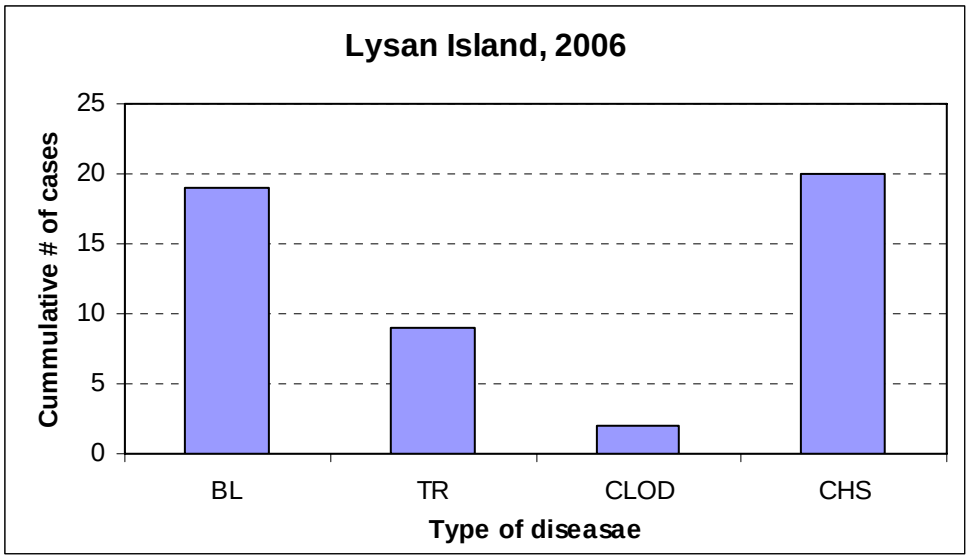

Figure F.3.2.3.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at Laysan Island during the 2006 RAMP cruise. BL: bleaching; TR: tremtodiasis; CLOD: coralline lethal orange disease; CHS: compromised health state.

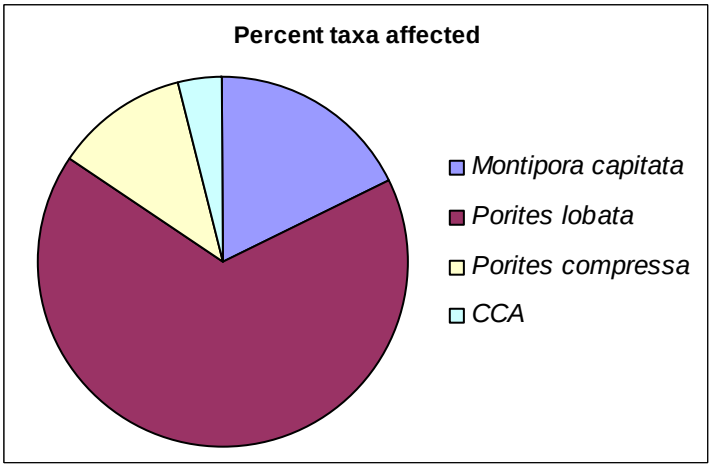

Figure F.3.2.3.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at Laysan Island, 2006. CCA: crustose coralline algae.

F.3.2.4 USFWS permanent coral transects

Two permanent transect sites were established at Laysan Island in September 2002 to track coral and visible macroinvertebrate population changes over time. Site LAY-1P is located in the west embayment on the north side of the large sand channel. Site LAY-5P is located on the shallow west reef crest, just south of the embayment and west of the NOAA buoy. Both sites were relocated and resurveyed on September 10, 2006. The 2002 surveys covered 37 m^2 and 25 m^2 while the resurvey covered 50 m^2 and 17 m^2, respectively. The tide was too low and wave action too strong to cover all 50 m^2 of site LAY-5P. All stakes at LAY-1P were relocated, and Yannis Papastamatiou and Carl Meyer kindly assisted in the

installation of new 3-foot stakes to better mark the ends of the transect. Both transects are sheltered from heavy winter swells from the northwest Pacific and offer more favorable habitats for corals.

Coral population parameters showed mixed trends over the 4-year period. Generic richness increased from three at both sites in 2002 to six and four genera at sites LAY-1P and LAY-5P, respectively in 2006. Mean diameters also increased at both sites, from 7.7 cm to 10.9 cm at LAY-1P and from 11 cm to 14.7 cm at LAY-5. However, coral frequencies (number of corals per m^2) dropped at both sites, dramatically at LAY-1P from 9.5 to 4.9 and less so at LAY-5P from 5.6 to 4.8 over the 4-year period. Overall, the number of smaller corals dropped dramatically at LAY-1P, while coral size distribution and numbers generally holding to the same distribution at the reef crest site LAY-5P. Although coral coverage estimates were not possible at the time of this report, 2006 observations indicate that the precisely calculated 2002 levels of 4.6% at LAY-1P and 7.4% at LAY-5P have not changed much. (See Figs. F.3.2.4.1 and F.3.2.4.2). About 10% of the corals, mostly *Porites lobata,* at LAY-1P appeared sick or dying, and overall coral health at this site appears less than reported there in 2002. There were few sick or dying corals at the reef crest site LAY-5P, and live coral cover may have increased over the 4 years.

Laysan is the northernmost non-atoll in the Northwestern Hawaiian Islands (NWHI). Its smaller oval shape renders it vulnerable to severe exposure to waves from the west to northeast, and the large winter swell from the northwest may prevent development of large, high profile corals. The lobe coral *Porites lobata* followed by the rose/cauliflower coral *Pocillopora meandrina* continue to dominate the coral fauna at these sites as they do at most other semi-exposed sites in the NWHI. Although not measured during the 2006 surveys, benthic algal cover was especially high at the west channel site at LAY-1P, and algae is prolific at other sites. Aside from its small size, Laysan Island supports over a million breeding seabirds and significant monk seal and sea turtle populations. Together with seepage from its high nutrient-laden hypersaline lake, Laysan Island may be subsidizing substantial localized productivity from local nutrients which, in turn, may favor the growth of algae over zooxanthellate corals in most shallow reef habitats. These factors may help explain the continued low degree of coral development at the permanent transects and at other reef sites at Laysan observed over the past several years.

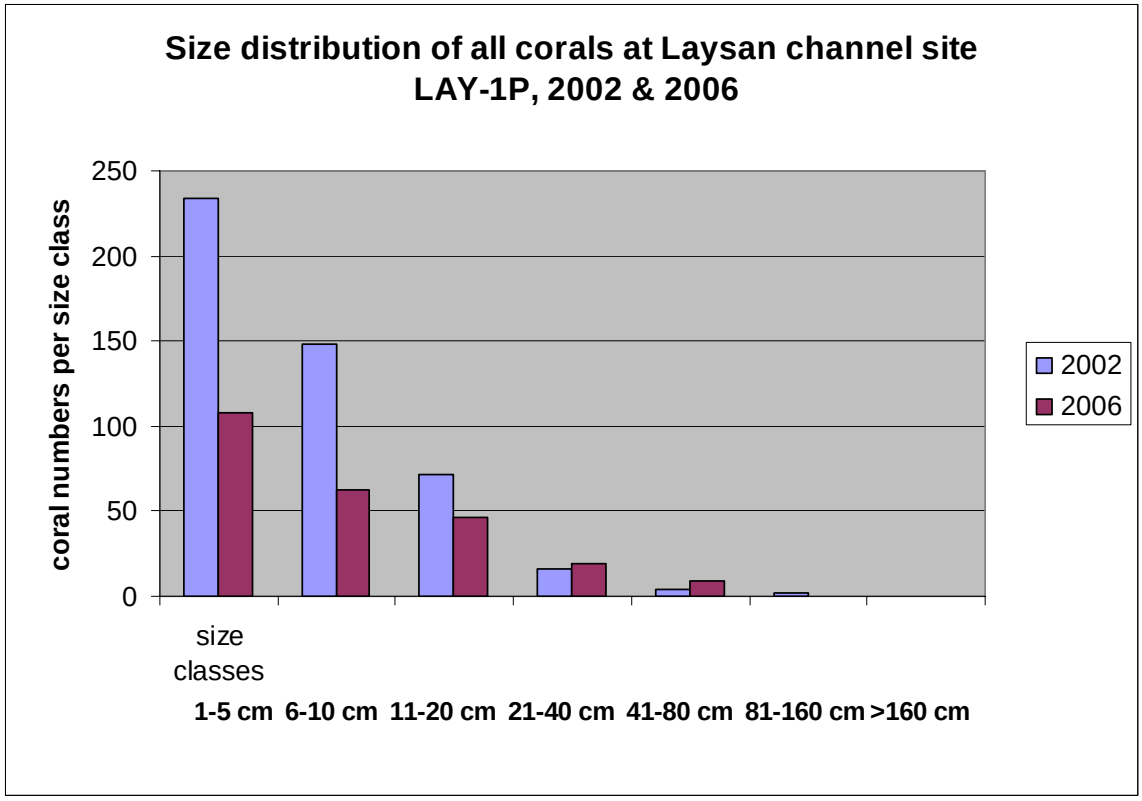

Figure F.3.2.4.1 Size distribution of all corals at Laysan Island site LAY-1P.

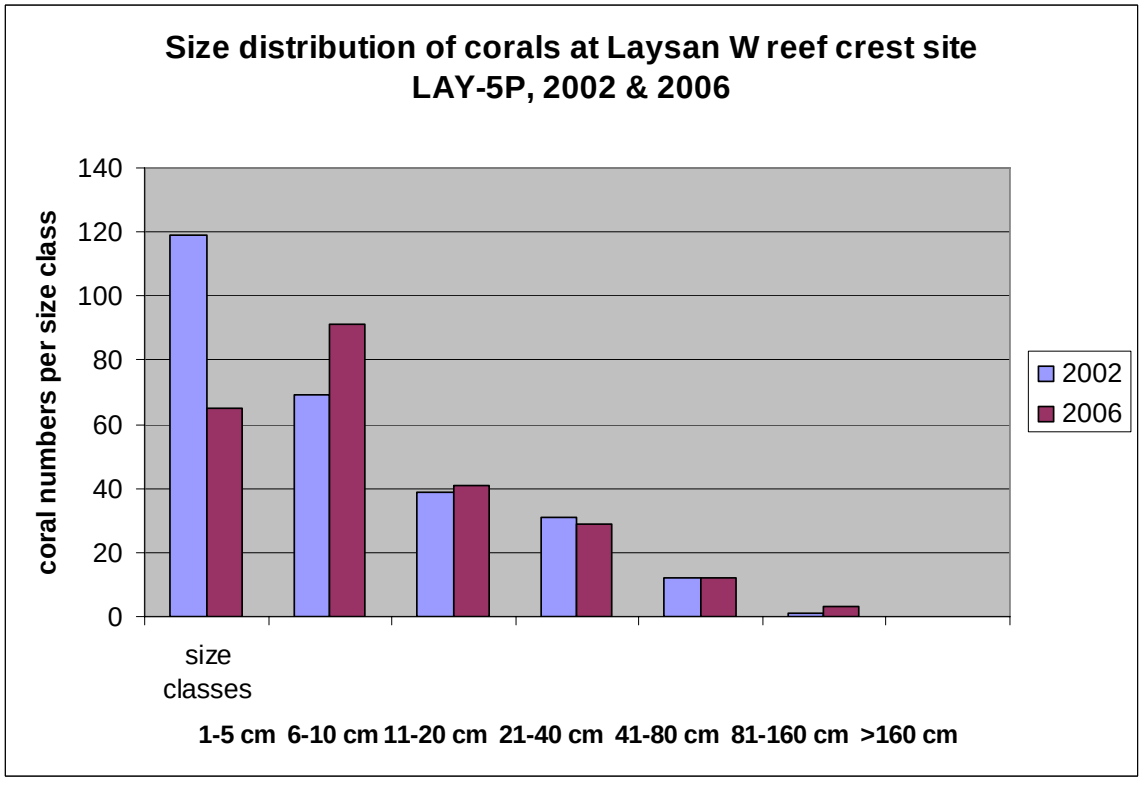

Figure F.3.2.4.2 Size distribution of all corals at Laysan Island site LAY-5P.

F.3.3 Towed-diver Benthic Surveys

During the six towed-diver habitat surveys conducted at Laysan Island, continuous reef and spur and groove bottom was recorded as the predominant habitat around the forereef slope of the island, along with several sand flat areas which increased along the southern section. Complexity varied, being low around sand flats, and medium to medium-high around the east, north, and west-facing shores where the continuous reef and spur and groove habitats were most prevalent.

The overall live coral cover was recorded at 9.4%, with an increase noted during the northwest towboard survey (16.5%). Macroalgal cover remained relatively uniform around the island at 33.2%. The highest macroalgae cover was noted during the last survey along the western forereef (68.2%), which was comparably deeper than the others. *Halimeda* species was also recorded in 47% of all recorded time segments. Overall coralline algae cover was recorded at 12.8%, but was comparably higher along the northern forereef (44%).

Notable increases in species of sea urchins were documented in the (deeper) western survey. Sea cucumber numbers remained low, with no more than five individuals recorded during any one time segment. Finally, only one crown-of-thorns starfish was noted during all towboard surveys of Laysan.

F.4 Fish

F.4.1 REA Fish Surveys

SPC data

A total of 179 fishes of 19 species were seen in stationary point count (SPC) surveys at the three Laysan sites (60 fishes/dive), and 168 of the fishes (94%) were 50 cm or smaller. While there was an obvious paucity of large predators (only one white-tip shark was seen by one diver the whole day), there were numerous large *Chlorurus perspicillatus* (33 counted by SPC divers in three dives, 8 were 50 cm or larger). After *C. perspicillatus* , the most numerous fishes counted in SPCs were *Naso unicornis* (22), *Naso brevirostris* (18), *Melichthys niger* (18), *Monotaxis grandoculus* (18), and *Acanthurus olivaceous* (13). There were few carangids counted: two *Caranx ignobilis* and eight *Caranx melampygus*.

BLT data

A total of 920 fish of 60 species were counted at the three sites on BLT transects. This reflects a fish density of 0.51 fishes/m^2. By far, the most numerically abundant species was *Thalassoma duperrey* (167 individuals counted). Also numerous were *Acanthurus leucopareius* (82 individuals counted), *Stegastes fasciolatus* (68), *Abudefduf abdominalis* (56), and *Acanthurus nigrofuscus* (56). The size frequencies of all fishes counted are presented in Figure F.4.1.1.

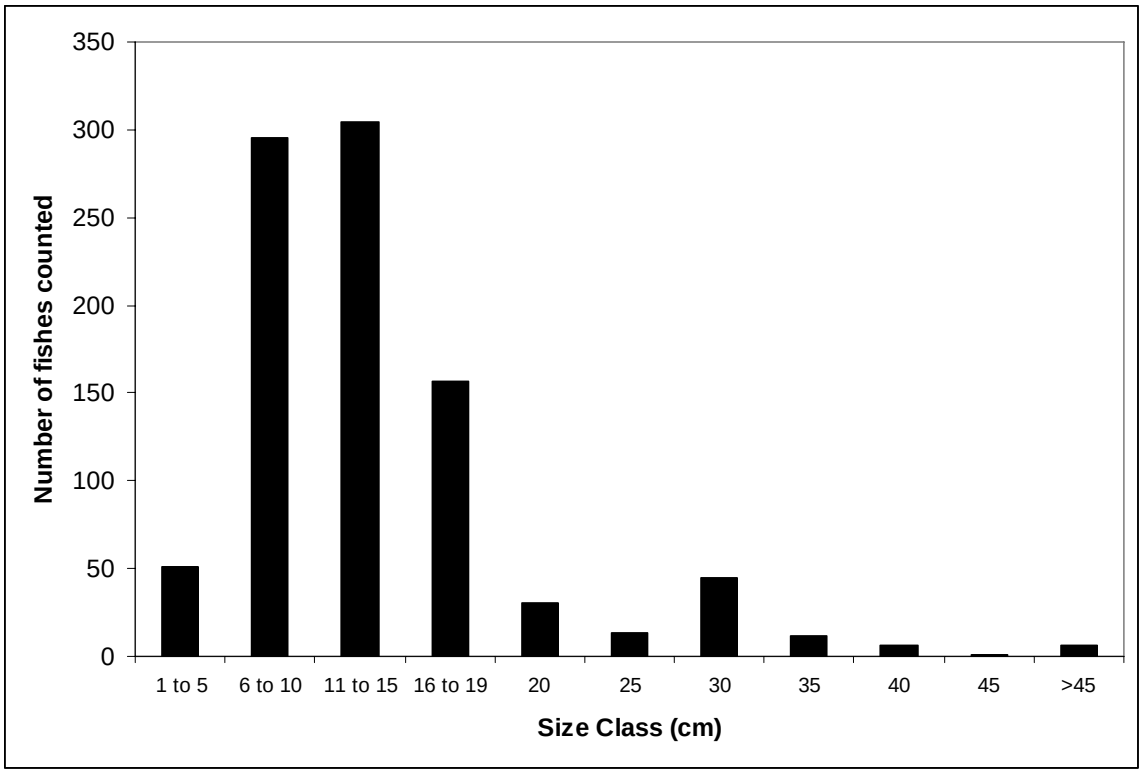

Figure F.4.1.1. Size frequencies of fish at Laysan Island.

Six fishes larger than 45 cm were seen on BLT transects.

Overall observations:

In total, 87 species were observed by the three fish divers on the three dives. The topography was interesting, with lots of swim-throughs and shelter for fishes. For some reason, we did not see any sharks to speak of, but there were lots of big parrotfish. This site was dominated by surgeonfishes.

F.4.2 Towed-diver Fish Surveys

Table F.4.2.1 HI06_11 Towed-Diver Survey Report for Laysan Island.

			Survey Length				Mean Depth
		N	Min	Max	Median	Sum	Median
Laysan Island	**09/10/2006**	6	1.69	3.08	2.58	7.34	-10.94
	All	6	1.69	3.08	2.58	7.34	-10.94

N = number of surveys conducted.
Survey Length is given in kilometers.
Depth readings are taken at 5 sec intervals during each 50 min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of nine species of fishes representing six families were observed at Laysan Island during the survey period. The mean number of fishes (> 50 cm TL) was 0.112 ha^{-1} and the five mostly commonly recorded species are shown in Figure E.4.2.1. The spectacled parrotfish (*Chloruus perspicillatus*) was the most commonly observed species during the quantitative surveys with a mean number of 0.91 fishes observed per hectare.

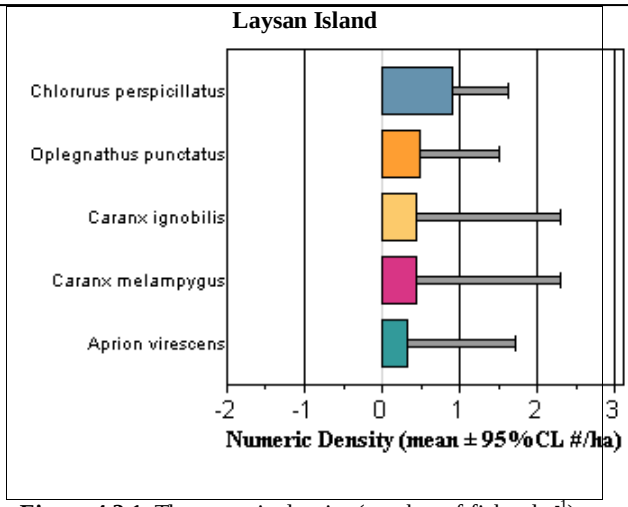

Figure 4.2.1. The numeric density (number of fishes ha^{-1}) of the 5 most commonly observed fishes at Laysan Island during the survey period.

The grand mean biomass density of fishes observed on the shallow reefs (<30 m) at Laysan Island during the survey period was 7.95 x 10^{-4} t ha^{-1}. More than 60% of the total fish biomass at Maro Reef consisted of giant trevally (*Caranx ignobilis*) (Fig. F.4.2.2).

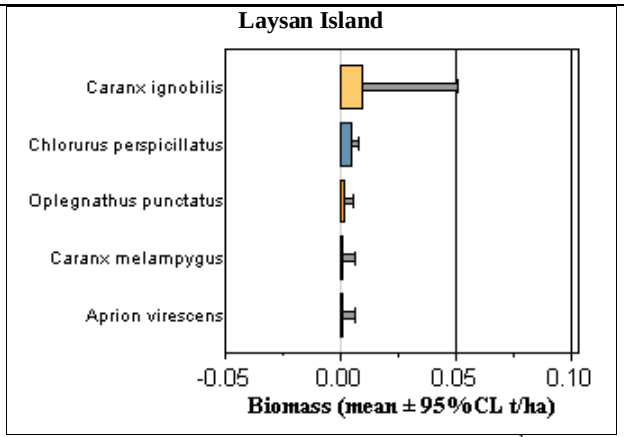

Figure F.4.2.2. The total grand mean biomass (t ha^{-1}) of the 5 most commonly observed fishes at Laysan Island during the survey period.

F.4.3 Shark Receivers

We deployed two new receivers on sand screws at locations described in Table A.5.2.

F.5 Maps

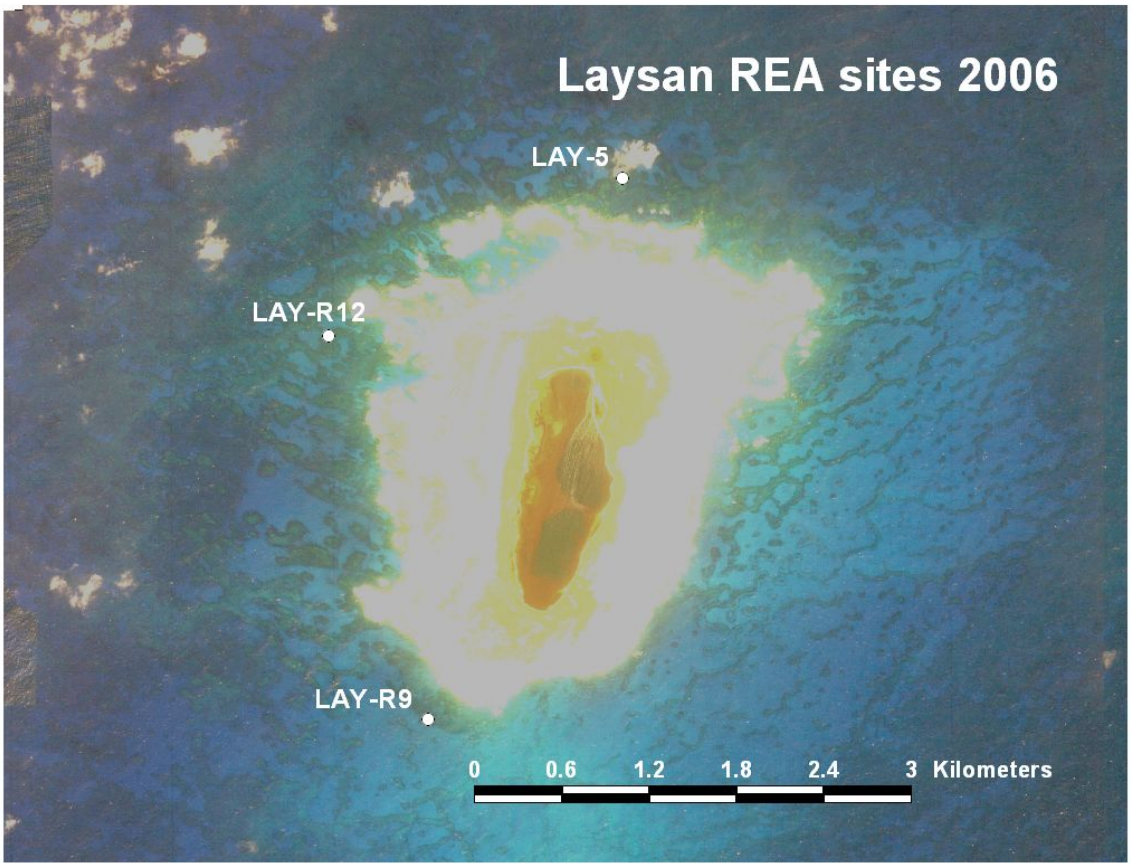

Figure F.5.1. Map showing location of 2006 Rapid Ecological Monitoring (REA) sites at Laysan Island.

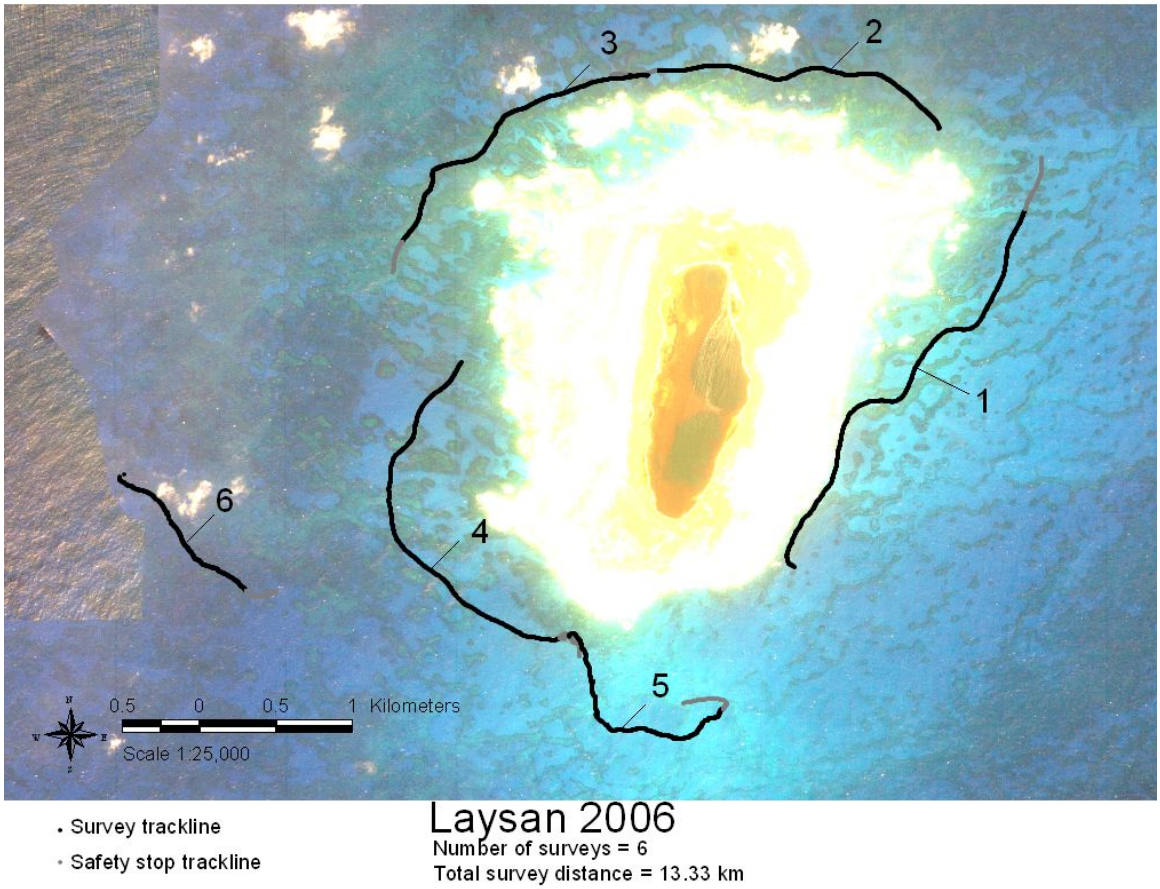

Figure F.5.2. Map showing location of towboard tracks at Laysan Island.

Appendix G: Pearl and Hermes Atoll

G.1. Oceanography and Water Quality

Instrument Deployments: Temporary

Observational reports of a significant shallow thermocline during the HI0401 Reef Assessnent and Monitoring Program (RAMP) cruise followed by a subsequent investigation by the oceanography team led to the deployment of a subsurface temperature recorder (STR) at 23 m along the south shore of Pearl and Hermes Atoll (27.78168 N, -175.88089 W). Based on this initial investigation, a temporary data array was deployed during HI0611 on September 13, 2006 and removed September 22, 2006. This array consisted of an RDI ADCP (Acoustic Doppler Current Profiler) used to measure current fluctuations and five STRs measuring temperature fluctuations. Three STRs were placed vertically above the ADCP on a subsurface buoy line at 13-m, 26-m, and 38-m depths. Two additional STRs were placed on permanent STR sites in a cross-shore array at 13-m and 23-m depths *(*Figure G.1.1 shows temporary deployment schematic). These five temporary STRs were set to record an average temperature reading every 300 seconds to give a higher resolution than the 1800 second averages for the 2-year STR deployments.

Instrument Deployments: Permanent

One Coral Reef Early Warning System (CREWS) buoy and CREWS buoy anchor was removed and replaced *(*Fig. G.1.2.*)* near the center of the atoll. A Seabird 39 temperature recorder was also attached to the CREWS buoy arm. Seven STRs were replaced and five additional STRs were deployed (Fig. G.1.2.). All STRs were set to record temperature every 30 minutes. The five new deployments were part of two, three-instrument, cross-shore (shore normal) arrays on the north and south of the atoll (Fig. G.1.2*)*. These arrays were deployed to further study the cold water pulses observed from data recovered from HI0401. In addition, an ODP (Ocean Data Platform) was deployed in the same region at a 21-m depth to monitor the local current regime, and to be used in conjunction with the permanent southern STR array to study apparent regular, shallow, thermocline excursions in the area. Finally, an EAR (Ecosystem Acoustic Recorder) was deployed in 10 m near one of Carl Meyer's fish listening stations on the south side of the atoll near the main boat channel. This instrument was deployed to measure the acoustic signals from both biological activity and boat traffic.

A total of 25 shallow-water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Pearl and Hermes following the 30-m contour. One cast was taken within the lagoon at the CREWS buoy site. Nineteen of these casts were conducted during the first period on September 13 and the last seven were conducted on September 22. At 5 of these locations, water sample profiles (at 1-m, 10-m, 20-m, and 30-m depths) were performed for a total of 20 water samples measuring chlorophyll and nutrients levels. In addition, one CTD profile and surface water sample was obtained near the CREWS buoy in the central lagoon.

Preliminary Results

For unknown reasons the RDI ADCP deployed in the temporary array recorded no data during the deployment. All STR recorders worked as programmed. The south shore of Pearl and Hermes was observed to have significant temperature fluctuations at shallow depths. Fish tow and fish REA surveys show large numbers of planktivorous fish in this area suggesting that these cold water pulses may be injecting nutrient rich waters to this region. A 2-year temperature time series from a single STR at 23 m (Fig. G.1.3. upper) shows the expected annual fluctuation of approximately 10^0 C with seasonal variation; however, during the months of June through November, higher frequency fluctuation (Fig. G.1.3. lower) shows excursions of up to 7 °C over time scales of 6 to 12 hours.

The temperature time series from the temporary STR array show similar significant diurnal, to semidiurnal fluctuations, with deeper sensors experiencing significantly more pronounced temperature excursions than those in shallower water (Fig. G.1.4.). The deepest (37 m) STR recorded the largest excursions of temperature, with diurnal excursions of varying degrees being recorded every day of the deployment.

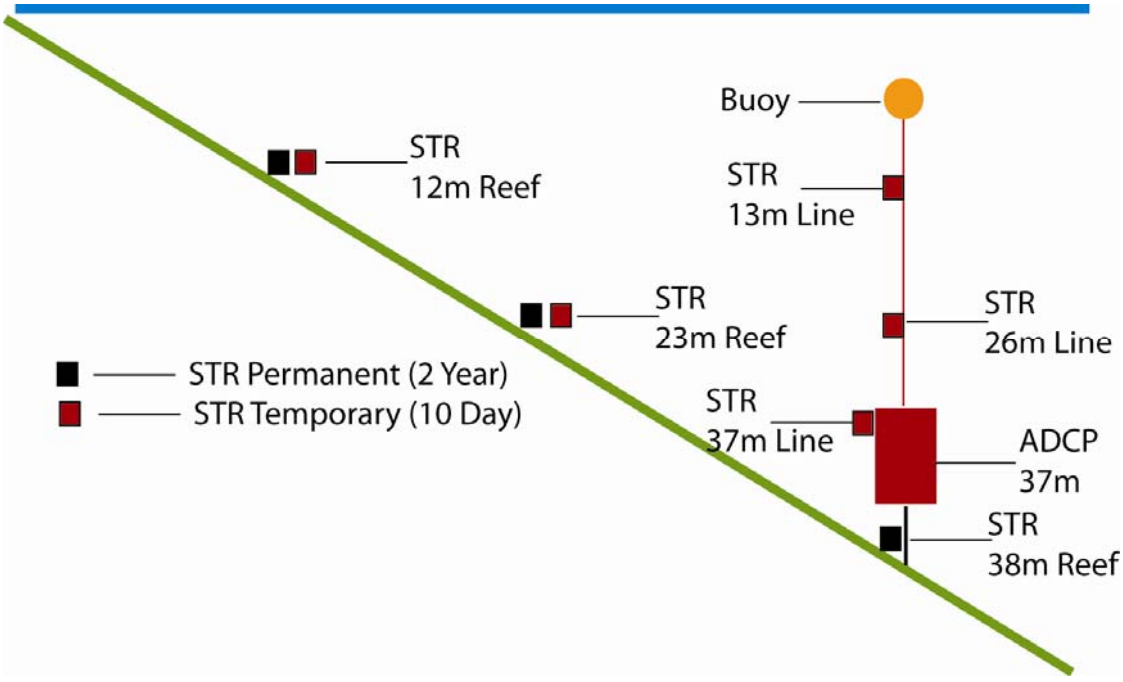

Figure G.1.1. Schematic of the Temporary South Shore Array.

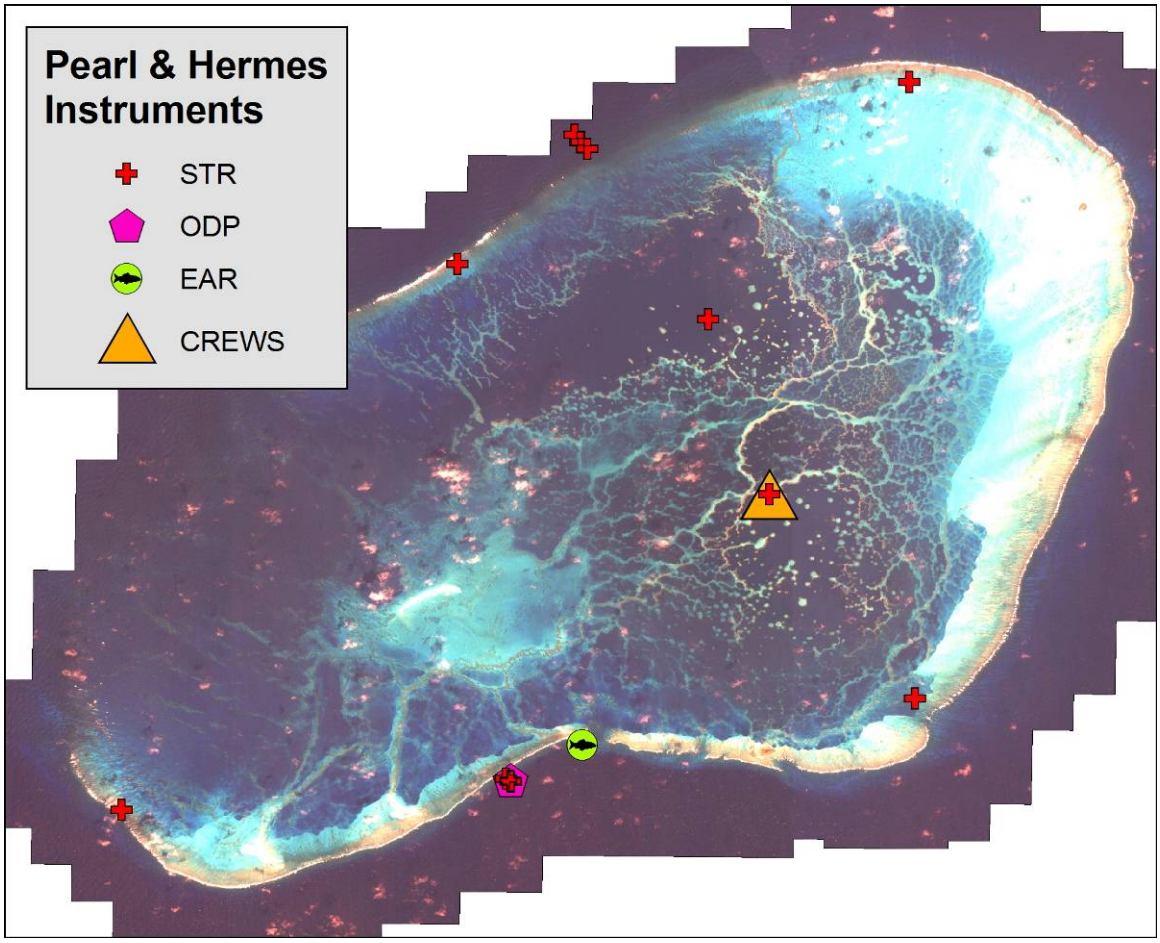

Figure G.1.2. ICONOS satellite image of Pearl and Hermes Reef with all permanent deployments marked.

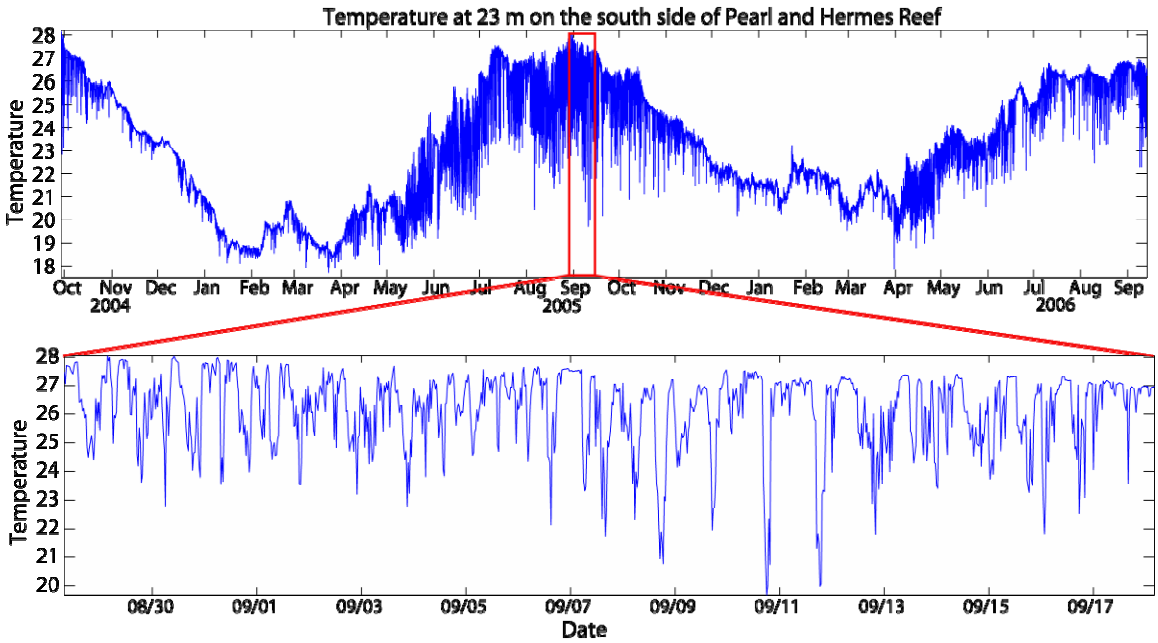

Figure G.1.3. Two-year timeseries from permanent STR deployment in 23 m of water, on south side of Pearl and Hermes (top panel). A 3-week expansion shows substantial temperature fluctuations (3-8°C) occurring on diurnal and semidiurnal periods.

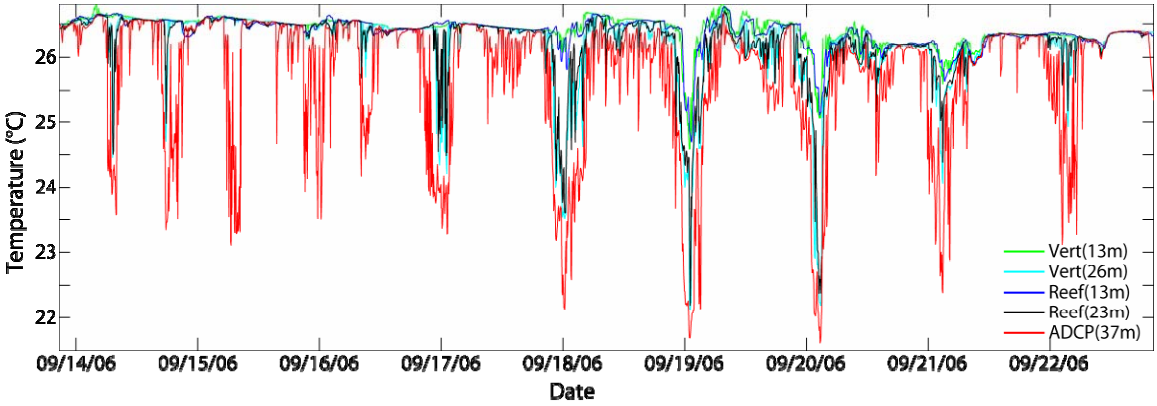

Figure G.1.4. Temperature time-series from STRs on the temporary array. Large temperature fluctuations of up to 5°C occurred over relatively short time periods (6-12 hours) daily.

G.2. Rapid Ecological Assessment (REA) Site Descriptions

PHR-R32
September 12, 2006

East, shallow backreef. Depth range: 0.9–1.2 m. Visibility ~12 m. Coral and coralline pavement and rubble heavily epiphytized by macroalgae and turf algae. Limited topographic complexity. It had been previously decided (by Kenyon, Vroom, and Vargas) to reposition site R32 (surveyed in 2002, 2003, and 2004) 500 km to the south in 2006 in order to utilize permanent transect markers installed by Greta Aeby in 2005 (same habitat).These markers were located and used in present survey. This very shallow backreef region experienced

strong surge and current from the adjacent forereef area. Waves were breaking over us as we were attempting to collect data while snorkeling. The area contained dense and diverse algal populations. Within photoquadrats we recorded: turf algae, *Microdictyon setchellianum, Ganonema farinosum, Dictyosphaeria versluysii, Laurencia galtsoffii, L.* sp., *Halimeda velasquezii*, non-geniculate branched calcified red algae, and *Lobophora variegate*. Algal- and sand-coated carbonate and rubble. *P. lobata* most common coral. Numerous dead pocilloporids covered with coralline algae. Low coral cover (5.8%); mainly composed by *Porites lobata* and *Pocillopora damicornis*. In 2004, there was substantial bleaching in pocilloporids at site R32 (75% of *P. meandrina* and 93.9% of *P. damicornis* pale or bleached). Four scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Pocillopora damicornis* and *P. ligulata*) observed in larger area outside belt transects. Macroalgae and turf algae accounted for 50% of the benthic cover.

Coral disease and health assessment: Within the survey area (300 m^2) six cases of trematodiasis were detected on *Porites lobata*. In addition, two cases of compromised health condition as a result of *Acanthaster* predation were noted on *Pocillopora*, as well as one case of pigmentation response on *Porites lobata*. This extremely shallow site was dominated by small wrasses and *Scarus psittacus.* Two *Caranx ignobilis* were counted by the SPC diver. This site was exceedingly species depauperate and had very few species.

PHR-R31
September 12, 2006

East-southeast. Inside lagoon reticulate reef; forereef slope. Depth range: 10.7–16 m. Visibility <10 m relief. Slope (~45^o) of southeast lagoon patch reef composed almost exclusively of dense thickets of *Porites compressa*. Necessary to anchor in adjacent sand patch, swim over shallow (2 feet) crest to slope and descend; Global Positioning System (GPS) coordinates taken by swimmer at float marking start of transect lines. New permanent transects installed; inner lagoonal reef slope containing dense *Porites compressa* thickets. Lower branches of coral colonies covered in dense turf algae with occasional crustose coralline red algae or cyanophyte patches. A few populations of *Caulerpa macrophysa* were observed growing among coral fingers, but did not appear in photoquadrats. Higher up on the reef slope (~1.5 - 4.6 m depths), *Halimeda opuntia* and large individuals of *Laurencia galtsoffii* were collected. Moderately high coral cover (47%), dominated and composed of delicate *Porites compressa* thickets. Minimal bleaching observed, unlike 2004 when ~10% of *P. compressa* was pale/bleached. Water temperature (79^{o}F) 2 degrees F. cooler in 2006 than same time of year in 2004. Five scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects. Turf algae growing on dead *Porites compressa* accounted for 50% of the benthic cover.

Coral disease and health assessment: Within the survey area (300 m^2) three cases of focal to diffuse bleaching were observed on *Porites compressa*. Additionally, two cases of trematodiasis and one case of tissue loss and pigmentation response were also observed on *Porites* compressa. Within the survey area, several (3) cases of compromised health as a result of overgrowth by cyanobacteria were noted on *Porites compressa*. This site was dominated by parrotfishes. Oddly, very few acanthurids were seen at this site. There was

plenty of shelter in the *Porites compressa*, but very few fish. The SPC diver saw one *Caranx ignobilis* the entire time. This site reminded us all of Kaneohe Bay!

PHR-R26
September 12, 2006

East-southeast, moderately-low relief spur-and-groove on ocean fringing forereef. New permanent transects installed, transect depth range: 12–14.6 m. Visibility ~20 m. Coral and coralline pavement and rubble heavily epiphytized by macroalgae and turf algae. Moderate topographic complexity. Benthos moderately highly bioeroded (abundant urchins). This deep forereef site was characterized by dense populations of *Microdictyon setchellianum*. Besides *Microdictyon*, turf algae, crustose coralline red algae, a diminutive species of *Padina*, a species of *Laurencia, Halimeda velasquezii, H. discoidea*, non-geniculate branched calcified red algae, encrusting *Lobophora variegata*, and a species of *Neomeris* were recorded. A species of *Liagora* and *Dasya iridescens* were collected during the random swim. Moderately low coral cover (12.7%), mainly composed by an assemblage of *Porites lobata* and *Pocillopora damicornis*. No bleaching observed, unlike 2004 when ~16% of pocilloporids were pale. Water temperature (77^{o}F) 2 degrees F. cooler in 2006 than same time of year in 2004. Seven anthozoan species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Fungia scutaria, F. granulosa*) observed in larger area outside belt transects. Other scleractinian corals observed outside the point-count survey transect included: *Cyphastrea ocellina, Pavona varians, Leptastrea purpurea, Porites evermanni/lutea, Psammocora stellata*, and *Porites solida*.

Coral disease and health assessment: Within the survey area (300 m^2) one case of bleaching and one case of trematodiasis on *Porites lobata* were observed. In addition, one case of compromised health condition as a result of *Acanthaster* predation was noted on *Porites* cf. *solida* sp. This site contained high diversity, and 92 species of fish were counted by 1 fish diver. This site was dominated by *Chromis spp.* and other damsels. Wrasses were also abundant and diverse. The SPC diver saw very few large fishes, but a lot of small fish all over the place. Rare and unusual sightings included the *Apolemi arcuatus, Pseudanthias thompsoni, Genicanthus personatus, Coris ballieui, Xanthichthys mento, Calotomus zonarcus,* and *Chaetodon kleinii*.

PHR-R42
September 13, 2006

South-southwest, fringing forereef; depth range: 11.3–15.5 m, visibility ~30 m; temperature: 25°C. Installed new permanent transects (2, 25 m). Carbonate pavement and rubble heavily bioeroded and epiphytized by macroalgae and turf algae; sparse sand pockets. Numerous *Echinometra* and *Echinostrephus* on the carbonate terrain, sheltered in bore-holes. Moderate topographic complexity. The southern facing forereef site was dominated by dense beds of highly epiphytized *Microdictyon setchellianum*. Interspersed among the *Microdictyon* were small individuals of *Halimeda velasquezii, H. discoidea*, encrusting *Lobophora variegata, Dictyosphaeria versluysii, Laurencia* sp., a non-geniculate calcified branched red alga, and a species of *Neomeris*. Low coral cover (6.8%); mainly composed of

Porites lobata, *Leptastrea purpurea*, *Psammocora stellata* and well-pigmented *Pocillopora meandrina*. Macroalgae and turf algae accounted for 65% of the benthic cover. *Acanthaster* and signs of predation on *P. meandrina* obvious at site, as in 2004. Seven anthozoan species (six scleractinian species and *Palythoa*) enumerated within 50 m^2 belt transects. One additional scleractinian species (*Fungia granulosa*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2) 11 cases of compromised health condition as a result of *Acanthaster* predation were noted on *Pocillopora*, *Leptastrea*, and *Porites lobata*. No other afflictions to corals were observed within the survey area. This site was dominated by lots of damsels, small surgeons, wrasses, and hawkfishes. We did see *Genicanthus personatus*, *Chaetodon kleinii,* and *Xanthichthys mento* again, and the SPC diver saw mainly triggerfishes and surgeons. There were some *Aprion virescens* keeping their distance, and a small school (approx. 20) of *Caranx ignobilis* keeping divers company. A half dozen Galapagos sharks came in at the end to brighten our day.

PHR-31
September 13, 2006

South-southwest. Inside lagoon reticulate reef; forereef slope. Depth range:
6.4–9.1 m, visibility <10 m, temperature: 26°C. This was a well-protected, lagoonal reef slope dominated by montiporid corals. Transects along side of *Montipora capitata* mounds, with areas of fine sand between mounds. Site bordered by sand flats or channels of very fine white silt occurred between coral ridges. Only turf algae, crustose coralline red algae, a species of *Neomeris*, and a small amount of *Microdictyon setchellianum* were recorded in photoquadrats. Dense patches of *Halimeda opuntia* and small individuals of *H. velasquezii* were encountered during the random swim. Live coral cover amounted to 26.4%, dominated by colonies of *Montipora capitata*. *M. capitata* moderately fissioned, well-pigmented, with dead areas in between, epiphitized by turf algae. Transects in 2004 were more shallow, included numerous pocilloporids. Montiporids and pocilloporids bleached in 2004 (80.4% of *M. capitata (n* = 46*)*, 68.5% of *P. meandrina (n* = 146*)*) and in 2002. No other corals were observed along the point-count survey transect. Eight scleractinian species enumerated within 50 m^2 belt transects. Also, no additional anthozoan species observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (150 m^2) one case of focal to multifocal bleaching was observed on *Montipora capitata*. Additionally, one case of compromised health as a result of predation was also noted on *Montipora capitata*. This site was dominated by baby parrotfish (mostly *C. sordidus and S. psittacus*). The SPC diver saw one *Aprion virescens* and a couple *N. unicornis*. In general this site was turbid and depauperate and nothing to write home about.

PHR-30
September 13, 2006

South-southwest, shallow backreef. Depth range: 2–3 m, visibility ~20 m, temperature: 26°C. Installed new permanent transects (2, 25 m), transect depth range 6–8 feet. Heavily bioeroded carbonate/rubble. Carbonate pavement heavily bioeroded and epiphytized by macroalgae and turf algae; sparse rubble and sand pockets. Numerous *Echinometra* and *Echinostrephus* on the carbonate terrain, sheltered in bore-holes. This shallow backreef site experienced extremely high surge, allowing only half of our survey to be completed. The algal flora was very diverse. Within photoquadrats we recorded: turf algae, tufts of a translucent species of *Ceramium*, *Liagora pinnata*, crustose coralline red algae, *Stypopodium flabelliformae*, a small species of *Padina*, *Microdicyton setchellianum*, *Laurencia galtsoffii*, and *Dictyosphaeria versluysii*. *Dasya iridescens*, *Halimeda discoidea*, *H. velasquezii*, *Turbinaria ornata*, and a species of *Trichogloeopsis* were found during the random swim. Low coral cover (3.8%), composed of a sparse assemblage of *Pocillopora* spp. and *Porites lobata*. Dominated by *P. meandrina*, with numerous small (<20 cm) colonies. Colonies all well pigmented, unlike 2004 when 73.5% of *P. meandrina* (n = 34) and 60% of P. *damicornis* (n = 5) were pale/bleached. Numerous large, dead *P. meandrina* with thick coralline/turf algal cover. Dense algal cover (e.g., *Microdictyon*). Water temperature (79^{o}F) 4 degrees F. cooler in 2006 than same time of year in 2004. Five scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Pocillopora damicornis*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2) one case of compromised health condition as a result of *Acanthaster* predation was noted on *Pocillopora damicornis.* No further afflictions to corals were observed within the survey area. This very shallow site had little shelter for reef fishes. Belt transect snorkelers saw a few small juvenile wrasses and some *Stegastes fasciolatus*. SPC diver saw one huge *Naso unicornis* and that was it. At least our data entry was quick and simple!

PHR-33
September 14, 2006

South; ocean fringing forereef; depth range 10.6–12.7 m; visibility 25 m, water temperature: 25°C, which is 4°C cooler in 2006 than the same time in 2004. Installed new permanent transects (2, 25 m). Carbonate pavement and rubble heavily bioeroded and epiphytized by macroalgae and turf algae; sparse sand pockets. Numerous *Echinometra* and *Echinostrephus* on the carbonate terrain, sheltered in bore-holes. Moderate topographic complexity. This southern forereef site was dominated by extremely thick meadows of *Microdictyon setchellianum*. Additionally, turf algae, small individuals of *Halimeda discoidea*, *H. velasquezii*, crustose coralline red algae, a species of *Laurencia*, encrusting *Lobophora variegata*, non-geniculate calcified branched red algae, and *Dictyosphaeria versluysii*. *Liagora pinnata* was collected during the random swim. Live coral cover amounted to 3.9%, composed of a sparse assemblage of *Porites lobata* and *Pocillopora* spp. Four scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Cyphastrea ocellina*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2) six cases of compromised health as a result of predation (most likely *Acanthaster*) were noted. No further afflictions to corals were observed within the survey area. This site was very predator rich, we saw 25+ *Caranx ignobilis* of a range of sizes, several Galapagos sharks, a white-tip reef shark, a school of large *Aprion virescens*, a couple of rainbow runners, and some kava kava. On the belt transects, there was not much but a few wrasse. Fish were concentrated near sporadic shelter holes in the reef but our transects did not pass near one. Near the shelter holes were large schools of *C. ovalis* and *Pseudanthias thompsoni* and *Dascyllus albisella.* There were also quite a few *Ptereleotris heteroptera* about.

PHR-32
September 14, 2006

South-southwest, shallow internal lagoon reef slope. Depth range: 4.8–6.7 m, visibility ~15 m, water temperature: 25.6°C, which is 4°C cooler in 2006 than the same time in 2004. Slope (~15^o) of southwest lagoon patch reef, moderately low topographic relief. Used permanent transects (2, 25 m) installed by Greta Aeby in 2005. Carbonate pavement bioeroded and epiphytized by macroalgae and turf algae; sparse rubble and sand pockets. Abundant *Echinometra* on the carbonate terrain, sheltered in bore-holes. This shallow lagoonal reef was characterized by Pocilloporid corals, many dead skeletons of which had dense populations of a species of *Padina* growing on them. The substrate was dominated by *Microdictyon setchellianum*. Additionally, we found turf algae, *Dictyosphaeria versluysii*, *Halimeda discoidea*, *Liagora pinnata*, and a species of *Neomeris*. Low coral cover (2.9 %), composed of a sparse assemblage of *Pocillopora* spp., *Montiopora capitata* and *P. damicornis*. Other scleractinians present outside the point-count transect line included: *Porties lobata*, *Psammocora stellata*, *Cyphastrea ocellina*, and *Leptastrea purpurea*. Many of the colonies dominated by *Pocillopora meandrina* seemed pale. Numerous large, dead heads *P. meandrina*, heavily algal-epiphitized and with young pocilloporid colonies. Pocilloporids bleached in 2004 (74.8% of *P. meandrina (n* = 123)) and in 2002. Four scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2) 14 cases of compromised health condition were observed on *Pocillopora* spp.; one attributed to predation, and the rest because of algal (*Padina* and crustose coralline algae) overgrowth. No further afflictions to corals were observed within the survey area. The second site was dominated by wrasses, the majority of which were *Thalassoma duperrey*, *Coris venusta*, and nonterminal *Stethojulis balteata*. There were quite a few small *Dascyllus albisella* as well. The SPC diver saw a couple of surgeonfish and a couple of parrotfish, and nothing at all on two reps.

PHR-22
September 14, 2006

South; shallow backreef. Depth range: 1–1.5 m, by macroalgae and turf algae; sparse rubble, sand pockets, and solution holes. Similar visibility ~20 m, water temperature:

26.11°C. which is 4°C cooler in 2006 than the same time in 2004. South patch reef, low topographic relief, visibility ~50 feet. Installed new permanent transects (2, 25 m). Carbonate pavement heavily bioeroded and epiphytized to site PHR-30; abundant echinoid grazers (*Echinometra, Echinostrephus*) sheltered in bore-holes. Abundant marcoalgae (*Microdictyon*) and turf algae (63.7%). This shallow backreef site exhibited high surge. Algae encountered included: *Microdictyon setchellianum, Liagora pinnata, Halimeda discoidea, H. velasquezii*, non-geniculate calcified branched red algae, *Dictyosphaeria versluysii, Caulerpa serrulata,* and *Stypopodium flabelliformae*. *Turbinaria ornata* was found drifting on the surface. Low coral cover (4.9%), composed of a sparse assemblage of *Pocillopora* cf capitata and *Leptastrea purpurea*. Other corals present outside the point-count transect line included: *Pocillopora* cf. *damicornis, Psammocora stellata, Porties lobata*. Pocilloporids bleached in 2004 (43.5% of *P. meandrina (n* = 23)) and in 2002. Four scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2) no afflictions to corals were observed. This site was exceptionally depauperate, both in terms of abundance and diversity of fishes. We only saw a couple of razorfish, a wrasse or two, and one very large *Coris flavovittata.* Of note, off the transect was an extremely large school (thousands) of *Mulloidichthys flavolineata,* with some *Naso unicornis* and chubs mixed in.

PHR-34
September 22, 2006

West-southwest; ocean fringing fore reef; depth range 10.7–18.6 m; visibility 35 m, temperature: 25°C. Substantial topographic complexity; spur and groove system. Transects deployed perpendicular to axis of spur-and-groove system. Site was chosen on basis of *Acropora cytherea* sightings in area first made by towboard team and later confirmed by J. Maragos. Site surveyed to quantitatively record the presence of *Acropora cytherea* and document community structure composition and health condition at this site. Algae inside photoquadrats we documented as turf algae, *Lobophora variegata*, crustose coralline red algae, *Halimeda velasquezii, H. opuntia,* non-geniculate calcified branched red algae, *Microdictyon setchellianum,* and *Dictyosphaerica versluysii*. *Halimeda discoidea* and species of *Peyssonnelia*, *Neomeris*, and *Dictyota* were found during the random swim. Live coral cover was moderately high, amounting to nearly 20%, composed of a diverse assemblage *Porites lobata*, *Pocillopora meandrina, Montipora capitata, M. patula*; *Fungia scutaria, Pavona duerdeni*, and *Leptastrea purpurea*. Four *A. cytherea colonies* found by Kenyon and Vargas Angel (outside belt transects) within area ~1060 m^2. Good coral diversity. No permanent transects installed, as site not submitted to State in permit application. Thirteen anthozoan species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Acropora cytherea*) observed in larger area outside belt transects. Regardless of moderately low coral cover, this site was one of the most scleractinian species rich encountered thus far.

Coral disease and health assessment: Within the survey plot (250 m^2) one case of tissue loss was observed on *Montipora capitata*. In addition, 10 cases of compromised health

condition were observed on *Porites lobata*; these involved pigmentation responses with algal overgrowth. No further afflictions to corals were observed within the survey area. This site was dominated by damslefishes, predominantly *Chromis ovalis, Chromis verater, Abudefduf abdominalis, Chromis hanui,* and *Chromis vanderbilti.* Refreshingly, there were few *Stegastes fasciolatus.* There were still a fair few *Thalassoma duperrey* around, though. The SPC diver saw mostly *Caranx ignobilis, Melichthys niger,* and *Melichthys vidua.* Belt divers saw a HUUUUUUUGE *Gymnothorax flavimarginatus* along the belt. We also spotted an eagle ray.

PHR-31
September 22, 2006

Revisit; no REA survey; only coral team present (Kenyon and Vargas Angel). Assessment dive to verify montiporid coral encountered by Vargas Angel at the beginning of transect 1 on previous dive (09/13/06). Photographic material was procured to authenticate species ID.

PHR-ODP Site
September 22, 2006

Only Fish team was present at this location. Fish diversity was found to be the following: *Pseudanthias thompsoni, Chromis verater, Chromis hanui, Chromis ovalis, Caranx ignobilis* predominantly. Large proportion of rare/northern/deep water species, e.g., *Genicanthus personatus, Centropyge interrupta, Sargocentron ensifer, Neoniphon aurolineatus.* Depauperate of surgeonfishes, heavy on the planktivores.

PHR-*Halophila hawaiiana* bed
September 22, 2006

East-southeast; Inside lagoon, depth range 7.5–8 m; visibility 35 m. No REA survey; only benthic teams (algae, coral) present. Assessment dive to verify *Halophila hawaiiana* meadow. Extensive *Halophila hawaiiana* seagrass bed located close to the southeast backreef (near Southeast Island). Very fine sand was crisscrossed with large, healthy, but occasionally epiphytized leaves. On randomly scattered bits of rubble, we found *Spyridea filamentosa, Microdictyon setchellianum, Dictyosphaeria cavernosa,* cyanophytes, and species of *Padina, Liagora, Chondria,* and *Laurencia*. Occasional P*ocillopora* toward shallower rubble/turf field. Photographic material was procured.

PHR-R39
September 23, 2006

North; ocean fringing forereef; depth range: 11.0–14. m; visibility: 15 m; temperature: 25°C. New permanent transects (2, 25 m) installed. Spur-and-groove system with impressive topography of mounting, vertical dead coral build-ups, separated by deep depressions. Carbonate carved into numerous buttresses, mini-pinnacles, and overhangs with good coralline algal and moderate *Halimeda* cover. The northern forereef had restricted

visibility but amazing topography. Algal diversity was fairly high. Turf algae, crustose coralline red algae, and encrusting *Lobophora variegata* dominated the substrate. Macroalgae observed included *Halimeda velasquezii*, *H. opuntia*, *Portieria hornemannii*, *Dictyosphaeria versluysii*, *D. cavernosa*, *Microdictyon setchellianum*, *Haloplegma duperreyi*, and species of *Neomeris*, *Peyssonnelia*, *Codium*, and *Dictyota*. Low live coral cover was 2.9%; only three scleractinians (*Porites lobata*, *Pocillopora meandrina*, and *Cyphastrea ocellina*) were enumerated along the point-count transects. However, scleractinian species richness was relatively high in the general area. Two individuals of *Acanthaster planci* were observed within the vicinity of the survey area. Overall, *Pocillopora meandrina* and *Porites lobata* most common corals. Nine anthozoan species (eight scleractinian and *Palythoa*) enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Leptastrea purpurea* and *Porites evermanni*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (250 m^2), one case of tissue loss was detected on *Porites lobata*. Additionally, several cases of compromised health states were noted, including: one case of discoloration on *Montipora patula*; two cases of pigmentation response on *Porties lobata*, and two cases of *Acanthaster* predation on *Pocillopora* cf. *meandrina*. This site was dominated by surgeonfishes, particularly *Ctenochaetus strigosus*, and there were also lots of *Thalassoma duperrey* and *Stegastes fasciolatus.* The parrotfish were miniature, little bitty terminal males cruising around. There was a striking lack of hawkfishes. SPC diver saw *Caranx ignobilis* and *Chlorurus perspicillatus.* We saw a fair number of initial phase *Epibulus insidiator* at this site as well.

PHR-R44
September 23, 2006

West-northwest; ocean fringing forereef; depth range: 13.3–14.8 m; visibility: 15 m; temperature: 25°C. Used permanent transects (2, 25 m) installed by Greta Aeby. Spur-and-groove system with less impressive topography than prior site (PHR-R39). Carbonate and sand with high cover of moderately fissioned *Porites lobata*. Inside photoquadrats, we observed turf algae, *Halimeda velasquezii*, *H. discoidea*, *H. opuntia*, non-geniculate calcified branched red algae, *Lobophora variegata*, crustose coralline red algae, species of *Dictyota*, and cyanophytes. Live coral cover was moderately high, amounting to 27.4%. Fissioned colonies of *Porites lobata* dominated the benthic coral landscape; *Psammocora stellata*, and *Montipora capitata* were, in lesser numbers, also enumerated along the point-count transects. Nine anthozoan species (eight scleractinian and *Palythoa*) enumerated within 50 m^2 belt transects. One additional scleractinian species (*Fungia scutaria*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2), two cases of mild, focal bleaching were observed on colonies of *Porites lobata*. We also registered 7 cases of tissue loss, as well as 18 cases tissue of trematodiasis, all on *Porites lobata*. Additionally, numerous cases (32) of a compromised health condition involving pigmentation response on *Porties lobata*. This site had low fish abundance, predominantly *Thalassoma duperrey*, some smaller surgeons such as *Acanthurus nigroris* and *Ctenochaetus strigosus*, and there was a

large school of *Chromis ovalis* that did not fall on the transect, for the most part. SPC diver saw *Caranx ignobilis* and some large *Aprion virescens.* One diver saw a small school of *Katsuwonus pelamis* cruise overhead during the dive. We also saw a magnificent snake eel, *Myrichthys magnificus*.

PHR-24
September 23, 2006

North; shallow, internal lagoon patch reef slope. Depth range: 4.5–6.4 m, visibility ~4 m, temperature: 26°C. New permanent transects installed. Carbonate framework heavily colonized by *Halimeda*; also numerous Ark bivalves, penetrating the semi-exposed reef framework. Slope (~70^{o}) of patch reef densely covered with *Halimeda*. This was a very silty lagoonal site with poor visibility. Draperies of silt covered species of *Halimeda* hung over hard substrate. Inside quadrats we recorded turf algae, *Halimeda opuntia*, *H. velasquezii*, *H. discoidea*, *Dictyosphaeria versluysii*, non-geniculate calcified branched red algae, and crustose coralline red algae. *Dictyosphaeria cavernosa* and cyanophytes were found during the random swim. Low coral cover (11.7%), composed of sparse *Porites compressa* colonies (93%). Other scleractinians present along the point-count transect line included: *Psammocora stellata* and *Montipora capitata.* Seven scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Leptoseris incrustans* and *Tubastraea coccinea*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2) four cases of trematodiasis were noted on colonies of *Porites compressa.* This site was extremely depauperate, with the major fishes being small parrotfishes *Scarus dubius* and *Scarus psitticus*, and a small school of *Kyphosus spp.* came through. SPC diver saw *Caranx ignobilis* and *Caranx melampygus*, and there were quite a few large parrotfish above transect C in the shallows. A large *Seriola dumerlii* tried to eat one diver's clipboard during the REA.

G.3. Benthic environment

G.3.1. Algae

Quantitative algal surveys were conducted at 14 sites in the Pearl and Hermes Atoll (PHR-R-32, PHR-R-31, PHR-R26, PHR-R-42, PHR-R-30, PHR-R-31, PHR-33, PHR-32, PHR-22, PHR-34, PHR-B *Halophila hawaiiana*, PHR-R-39. PHR-R-44, PHR-R-24) The sites located in the north, east, and southern locations varied highly from shallow backreefs and patch reefs, internal lagoon sites and the fringing forereef. During the visit to Pearl and Hermes Atoll, scientists experienced strong surges and currents coming from the north. Multiple sites where characterized by carbonate pavement and rubble which was heavily bioeroded and covered by macro and turf algae with sparse sand pockets. Located in deeper sites in the fringing forereef, the spur and grooves added substantial topographic complexity to the terrain. This is a convenient habitat for a diverse algal flora to thrive. The commonly found green algal species included: *Halimeda opuntia, H. velasquezii*, *H. discoidea*, *Dictyosphaeria versluysii*, *Microdictyon setchellianum* and species of *Neomeris*. *Liagora, Laurencia*, non-geniculate calcified branched red algae, and crustose coralline red algae where amongst the most common red algae found throughout the atoll system. Common brown algal species found included *Lobophora variegata* and species of *Stypopodium*, *Dictyota*, and *Padina.* At one particular site, there was an abundance of beautiful *Halophila hawaiiana*, an endemic sea grass. Overall, 10 species of green algae, 12 species of red algae, and 5 species of brown algae were collected. Once microscopic examination of samples occurs, it is expected that epiphytes identified will increase the number of species collected substantially.

Table G.3.1.1: Algal genera or functional groups recorded in photoquadrats at Pearl and Hermes Atoll. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	PHR-R-32	PHR-R-31	PHR-R-26	PHR-R-42	PHR-R-30	PHR-R-31	PHR-33	PHR-32	PHR-22	PHR-34	PHR-B *Halophila hawaiiana*	PHR-R-39	PHR-R-44	PHR-24
GREEN ALGAE														
Dictyosphaeria	*41.7*	*0.0*	*0.0*	*25.0*	*8.3*	*0.0*	*16.7*	*8.3*	*0.0*	*8.3*	*0.0*	*16.7*	*0.0*	*16.7*
	4.8	**0.0**	**0.0**	**2.7**	**6.0**	**0.0**	**4.5**	**4.0**	**0.0**	**5.0**	**0.0**	**5.0**	**0.0**	**3.0**
Halimeda	*83.3*	*0.0*	*0.0*	*33.3*	*0.0*	*0.0*	*41.7*	*8.3*	*0.0*	*75.0*	*0.0*	*83.3*	*91.7*	*100.0*
	4.4	**0.0**	**0.0**	**3.3**	**0.0**	**0.0**	**3.2**	**4.0**	**0.0**	**3.3**	**0.0**	**3.8**	**3.9**	**2.3**
Microdictyon	*75.0*	*0.0*	*83.3*	*100.0*	*33.3*	*0.0*	*100.0*	*91.7*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*
	2.3	**0.0**	**6.0**	**2.1**	**3.3**	**0.0**	**1.4**	**1.6**	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**

	PHR-R-32	PHR-R-31	PHR-R-26	PHR-R-42	PHR-R-30	PHR-R-31	PHR-33	PHR-32	PHR-22	PHR-34	PHR-B *Halophila hawaiiana*	PHR-R-39	PHR-R-44	PHR-24
Neomeris	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*33.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*
	0.0	**0.0**	**6.0**	**0.0**	**0.0**	**2.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.5**	**0.0**	**0.0**
RED ALGAE														
Non-geniculate calcified branched red algae	*58.3*	*0.0*	*41.7*	*41.7*	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*	*50.0*	*0.0*	*0.0*	*33.3*	*0.0*
	4.1	**0.0**	**4.6**	**3.4**	**0.0**	**0.0**	**4.5**	**0.0**	**0.0**	**3.8**	**0.0**	**0.0**	**4.0**	**0.0**
Ceramium	*0.0*	*0.0*	*0.0*	*0.0*	*41.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**2.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
crustose coralline red algae	*25.0*	*33.3*	*50.0*	*33.3*	*33.3*	*8.3*	*41.7*	*0.0*	*0.0*	*58.3*	*0.0*	*100.0*	*91.7*	*8.3*
	4.7	**2.0**	**3.5**	**4.0**	**5.0**	**2.0**	**4.0**	**0.0**	**0.0**	**3.6**	**0.0**	**2.1**	**2.6**	**5.0**
Ganomema	*75.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	3.1	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Laurencia	*75.0*	*0.0*	*91.7*	*0.0*	*33.3*	*0.0*	*25.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	3.7	**0.0**	**3.2**	**0.0**	**5.3**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Liagora	*0.0*	*0.0*	*0.0*	*0.0*	*50.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**3.5**	**0.0**	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Peysonnellia	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*25.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**
Portieria	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.0**	**0.0**	**0.0**
BROWN ALGAE														
Dictyota	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**
Lobophora	*8.3*	*0.0*	*16.7*	*66.7*	*0.0*	*0.0*	*25.0*	*0.0*	*0.0*	*66.7*	*0.0*	*100.0*	*75.0*	*0.0*
	6.0	**0.0**	**5.5**	**3.0**	**0.0**	**0.0**	**3.3**	**0.0**	**0.0**	**2.3**	**0.0**	**3.1**	**3.2**	**0.0**
Padina	*0.0*	*0.0*	*16.7*	*0.0*	*16.7*	*0.0*	*0.0*	*91.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**4.5**	**0.0**	**5.0**	**0.0**	**0.0**	**2.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
FUNCTIONAL GROUPS														
turf algae	*100.0*	*100*	*100*	*50.0*	*50*	*100*	*100.0*	*100*	*0*	*100*	*0*	*100*	*100*	*91.66*

	PHR-R-32	PHR-R-31	PHR-R-26	PHR-R-42	PHR-R-30	PHR-R-31	PHR-33	PHR-32	PHR-22	PHR-34	PHR-B *Halophila hawaiiana*	PHR-R-39	PHR-R-44	PHR-24
	1.0	**1.0**	**1.2**	**1.5**	**1.0**	**1.0**	**1.6**	**1.7**	**0.0**	**1.0**	**0.0**	**1.6**	**1.0**	**1.8**
cyanophytes	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*8.3*	*0.0*
	0.0	**2.5**	**0.0**	**0.0**	**0.0**	**2.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**6.0**	**0.0**

Table G.3.1.2: Putative algal species found at Pearl and Hermes Atoll. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis.

List of putative macroalgal species collected (one sample per site)

	PHR-R-32	PHR-R-31	PHR-R-26	PHR-R-42	PHR-R-30	PHR-R-31	PHR-33	PHR-32	PHR-22	PHR-34	PHR-B *Halophila hawaiiana*	PHR-R-39	PHR-R-44	PHR-24
GREEN ALGAE														
Caulerpa macrophysa		X												
Caulerpa serrulata									X					
Codium sp.												X		
Dictyosphaeria versluysii	X			X	X		X	X	X	X		X		X
Dictyosphaeria cavernosa											X	X		X
Halimeda discoidea			X	X	X		X	X	X	X			X	X
Halimeda opuntia		X				X				X		X	X	X
Halimeda velasquezii	X		X	X	X	X	X		X	X		X	X	X
Microdictyon setchellianum	X		X	X	X	X	X	X	X	X	X	X		

Neomeris sp.			X	X		X		X		X		X		
RED ALGAE														
Non-geniculate calcified branched red algae	X		X	X			X		X	X	X		X	X
Ceramium spp.					X									
Chondria spp.											X			
Dasya iridescens			X		X									
Ganonema farinosum	X		X											
Haloplegma duperreyi												X		
Laurencia sp.	X		X				X				X			
Laurencia gattsoffii	X	X			X									
Liagora spp.					X		X	X	X		X			
Liagora pinnatum					X									
Peysonnellia spp.										X		X		
Portieria hornemannii												X		
Trichogloepsis sp.					X									
BROWN ALGAE														
Dictyota spp.										X		X	X	
Lobophora variegata			X	X			X			X		X	X	
Padina spp.			X		X			X			X			
Stypododium flabelliformae					X				X					
Turbinaria ornate					X				X					
OTHER														
Halophila hawaiiana											X			

G.3.2. Corals

Coral REA surveys were conducted at 12 of the 15 sites that were selected by CRED and partners in 2003 for long-term monitoring. Inclement weather on September 22 prevented the REA team from working at its remaining sites with northerly or western exposures; consequently sites PHR-26 (northern backreef), PHR-23 (west patchreef), and PHR-R22 (west backreef) were not surveyed in 2006. Both PHR-26 and PHR-R22 were surveyed by CRED in 2004, but site PHR-23 has not been surveyed since 2003. Because of this temporal gap, the REA team intended to survey PHR-23 in 2006, but the sighting of a tiger shark by coxswain Keith Lyons prevented the team from entering the water. Of the 12 sites surveyed in 2006, all had been most recently surveyed by CRED and partners in 2004, and 8 had been most recently surveyed by the NWHI Coral Reef Ecosystem Reserve in September 2005.

At four of these 12 long-term monitoring sites (PHR-R44, PHR-R32, PHR-31, and PHR-32) permanent transect markers had been installed by Dr. Greta Aeby in 2005 and were used by survey teams this year to guide deployment of transect lines (2, 25 m per site). Permanent transect markers were installed at the remaining eight sites this year along the first two transects by members of the REA fish team with the intention of reducing error because of spatial imprecision on future surveys. GPS site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded in order to facilitate relocating the markers on future surveys.

Because REA surveys could not be conducted at northerly or western sites on September 22, a full REA survey was conducted at a new site, PHR-34 on the southwest forereef (see section below concerning *Acropora cytherea*). In addition, site PHR-31 was revisited by the coral team to more closely examine a *Montipora* colony which had sparked taxonomic interest during the full REA survey on September 13. A third dive was conducted on September 22 by the coral team to accompany the CRED phycologist at a site where a *Halophila* (sea grass) meadow had been previously reported. However, because no quantitative surveys were conducted at this location ($27^{o}47.570$N, $175^{o}48.535$W), it is not listed as an REA site.

G.3.2.1 Coral populations

A total of 2319 colonies belonging to 17 anthozoan taxa were enumerated within belt transects enclosing 650 m^2 benthic substrate (Table G.3.2.1). The most frequently occurring taxa were *Porites lobata* and *Pocillopora meandrina*. Four additional scleractinian taxa not seen within belt transects were observed within the larger survey area surrounding the transect belts (*Acropora cytherea, Fungia granulosa, Leptoseris incrustans,* and *Tubastraea coccinea*).

The documentation of *Acropora cytherea* at Pearl and Hermes Atoll was a particularly significant finding, as this species had previously only been recorded as far north in the Hawaiian Archipelago as Laysan (Grigg et al., 1981; Maragos et al., 2002). Several colonies were reported and photographed by the benthic tow team following tow surveys

along the southwest forereef on September 13. As the photographs were suggestive rather than definitive, however, Carl Meyer and Jim Maragos conducted a reconnaissance dive based on GPS coordinates provided by the tow team on September 14; they located and photographed a single colony of this species, confirming the new record for Pearl and Hermes Atoll. On September 22, the REA team conducted a full REA survey (fish, corals, coral disease, algae) based on GPS coordinates provided by Carl Meyer to look for additional colonies and, as importantly, place any observations of this species in the context of a quantitative survey. This new site was designated as PHR-34. Coral biologists Jean Kenyon and Bernardo Vargas Angel located, measured, photographed, and recorded depth data for four additional colonies of *A. cytherea* within a search area of 53 m x 20 m (i.e., 1060 m^2). These data are being provided to Dr. Maragos, whose stated intention is to write a note intended for scientific publication concerning the new geographic record for this species.

Additionally, *Leptoseris incrustans* had not previously been reported from Pearl and Hermes Atoll (Maragos et al., 2002). However, this scleractinian species was observed and photographed by Kenyon at a northwest patch reef site (PHR-24) and by Vargas Angel at a southwest forereef site (PHR-34).

Table G.3.2.1. Number of anthozoans enumerated within belt transects at Pearl and Hermes Atoll during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Taxon	# of colonies	Percent of total
Acropora cytherea	0	0.0
Acropora valida	0	0.0
Acropora humilis	0	0.0
Montipora capitata	147	6.3
Montipora patula	23	1.0
Montipora verilli	0	0.0
Montipora flabellata	11	0.5
Montipora turgescens	0	0.0
Montipora incrassata	0	0.0
Pavona duerdeni	8	0.3
Pavona varians	6	0.3
Pavona maldivensis	5	0.2
Cyphastrea ocellina	35	1.5
Leptastrea purpurea	170	7.3
Fungia scutaria	56	2.4
Pocillopora damicornis	60	2.6
Pocillopora eydouxi	0	0.0
Pocillopora ligulata	2	0.1
Pocillopora meandrina	607	**26.2**
Porites brighami	0	0.0
Porites compressa	198	8.5
Porites evermanni	1	0.0
Porites lobata	860	**37.1**
Psammocora stellata	77	3.3

Taxon	# of colonies	Percent of total
Palythoa sp.	53	2.3
Zoanthus pacifica	0	0.0
Total # colonies	2319	100.0
Area surveyed, m^2	650	

A size class distribution of all corals enumerated within belt transects is shown in Figure G.3.2.1. Of the 2319 colonies whose maximum diameter was visually estimated, 69.1% had a maximum diameter <10 cm, and 3.8% had a maximum diameter >40 cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003–2004 surveys.

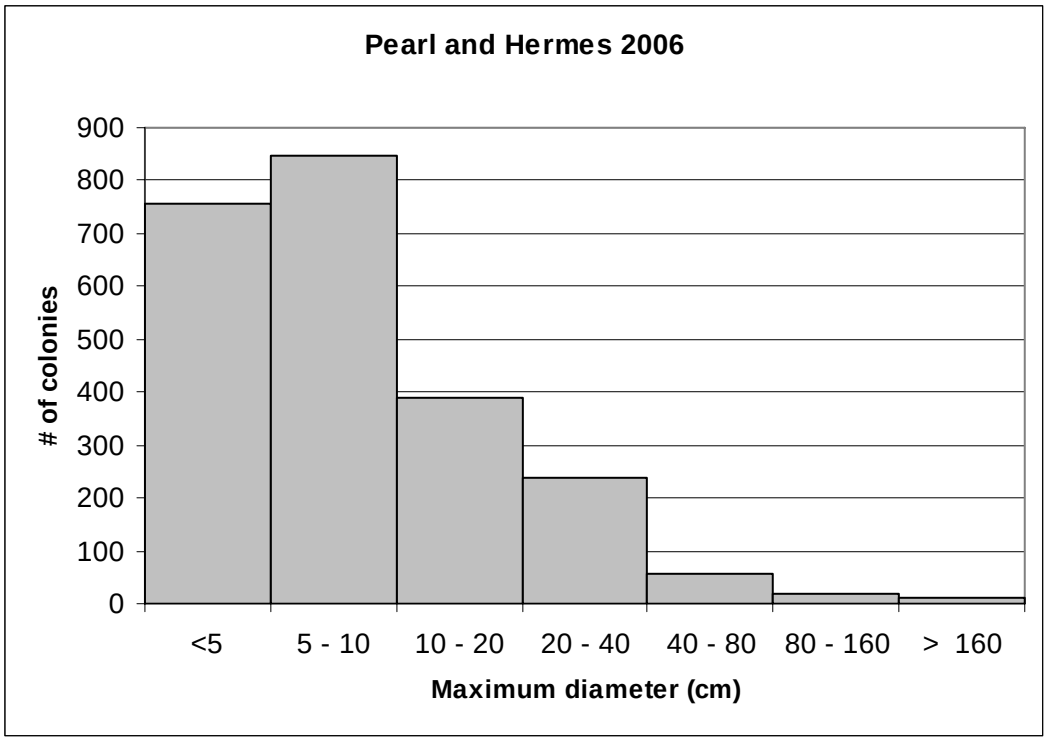

Figure G.3.2.1. Size class distribution of 2319 coral colonies enumerated within belt transects at Pearl and Hermes in 2006.

References

Grigg, R. W., J. W. Wells, and C. Wallace.
1981. *Acropora* in Hawaii. Part 1. History of the scientific record, systematics, and ecology. Pac. Sci. 35(1): 1-13.

Maragos, J. E., D. C. Potts, G. S. Aeby, D. Gulko, J. C. Kenyon, D. Siciliano, and D. VanRavenswaay.
2004. 2000-2002 Rapid Ecological Assessments of corals (Anthozoa) on shallow reefs of the Northwestern Hawaiian Islands. Part 1: species and distribution. Pac. Sci. 58(2): 211-230.

G.3.2.2. Percent benthic cover

Percent benthic cover surveys at Pearl and Hermes Atoll were conducted in congruency with the fish, coral population, and algae REA surveys at 13 different sites. The line-intercept methodology quantified a total of 1326 points along 650 m of coral reef communities, including forereef habitat, backreef environments, as well as lagoon patch reefs. Survey-transect depths ranged between 0.9–1.5 m at the back-reef sites and 6.7–13.6 m along the forereef locales. The point-count surveys indicated that the mean percent live coral cover for all sites combined at Pearl and Hermes Atoll was13.4%; comparable to the overall mean percent live coral cover estimated for Midway Atoll. At Pearl and Hermes, relatively high coral cover (>47%) was encountered at site PHR-R31 on the southeastern sector of the central lagoon. This dome-shaped patch reef was predominantly built and dominated by live *Porites compressa*. Sites PHR-31 on the southwestern back-reef, as well as PHR-R44 along the northern forereef, also exhibited moderately high (26–27%) percent live coral cover.

From the 20 scleratinian taxa reported for all sites combined at Pearl and Hermes (see above section on coral population dynamics by Kenyon), 11 were enumerated along the line-intercept transects (Table 3.2.2.1), with *Porites compressa* being the most numerically abundant (33.1%). This result, however, does not reflect the typical composition of the forereef and backreef habitats at Pearl and Hermes, where *Porites lobata* was the scleractinian taxon most commonly and abundantly encountered. Additionally, *Montipora capitata* was numerically the third, most abundant coral taxon encountered at Pearl and Hermes. Among the sites visited, this species was prolific only at site PHR-31, a patch reef on the southeastern lagoon; it was sparse at the fore and backreef sites.

Together macroalgae, turf algae growing over carbonate pavement, dead coral surfaces, and coral rubble accounted for over 50% of the biological benthos. Coralline algae and encrusting corallines amounted to 8% of the benthic cover. Macroalgae including *Halimeda* were particularly abundant (>45% percent cover) at sites PHR-24 and PHR-32; lagoonal patch reefs. Encrusting coralline algae, on the other hand, were particularly abundant at PHR-R39; a northern forereef site.

Below, Table G.3.2.2.1 provides a complete itemized analysis of percent cover for the different benthic elements enumerated using the line-intercept methodology at Pearl and Hermes Atoll. Additionally, Figure G.3.2.2.1 illustrates the contribution of the different scledractinain taxa to the total percent live coral cover.

Table G.3.2.2.1 Percent cover of the benthic elements at Pearl and Hermes Atoll using the point-intercept method during the 2006 REA activities.

Species	Total point counts	% Cover
Cyphastrea ocellina	1	0.1
Fungia scutaria	1	0.1
Leptastrea purpurea	6	0.5
Montipora capitata	31	2.3
Montipora patula	1	0.1
Pavona duerdeni	1	0.1
Pocillopora cf. *damicornis*	7	0.5
Pocillopora meandrina	14	1.1
Porites compressa	59	4.4
Porites lobata	55	4.1
Psammocora stellata	2	0.2
Halimeda	70	5.3
Macro-algae	233	17.6
Coralline algae	9	0.7
Pavement/turf	248	18.7
Pavement/cca	98	7.4
Dead/turf	112	8.4
Dead/cca	2	0.2
Rubble/turf	74	5.6
Rubble/cca	6	0.5
Rubble	18	1.4
Sand	180	13.6
Sand/turf	87	6.6
other	11	0.8
Grand Total	1326	

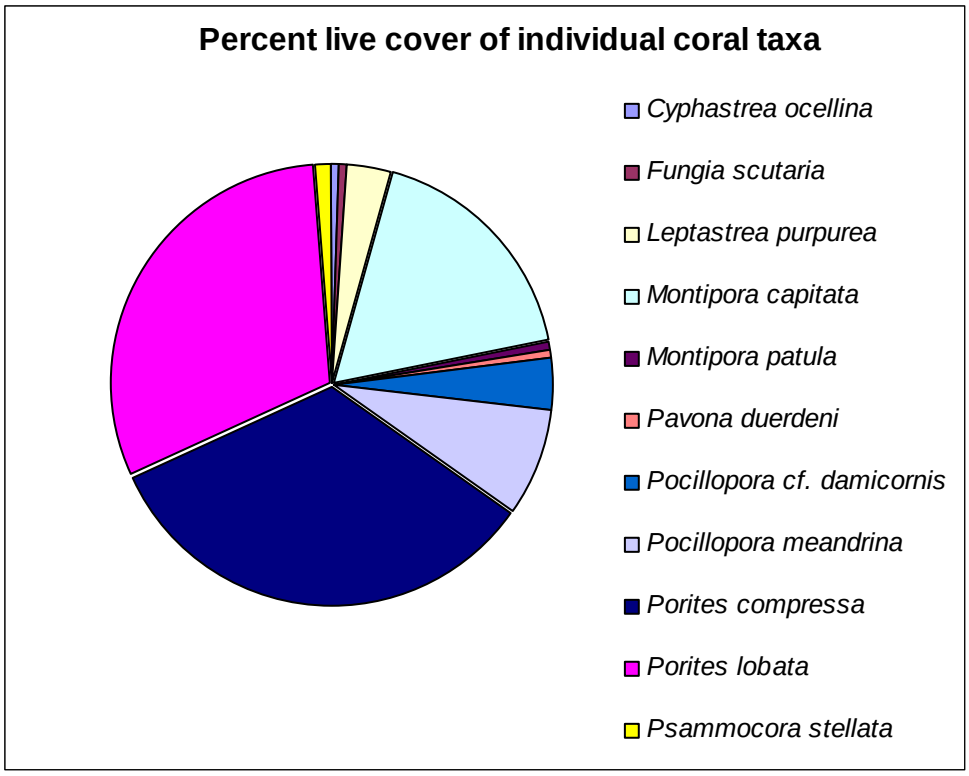

Figure G.3.2.2.1. Percent contribution of the different taxa to the total live coral cover.

G.3.2.3. Coral disease

At Pearl and Hermes Atoll, the coral disease REA surveyed a total area of approximately 3650 m^2 at 13 different sites during the RAMP cruise of 2006; this represents an average of approximately 300 m^2 at each survey site. Compared to the other two northernmost atolls (i.e., Kure and Midway) in 2006, corals at Pearl and Hermes exhibited a greater number of cases of disease as well as states of compromised health. In addition, unlike earlier REAs, no widespread bleaching was detected during our 2006 visit. Between 2002 and 2004 researchers Kenyon and Aeby reported the occurrence of significant coral bleaching, mortality, and phase shifts, particularly affecting backreef and lagoon sites at Pearl and Hermes. Also, between 2003 and 2004 Dr. Greta Aeby reported six different disease states for corals at Pearl and Hermes Atoll including: (1) *Porites* trematoidiasis, (2) *Porites* tissue loss, (3) *Porites* dark tissue thinning, (4) Porites brown necrotizing disease, (5) *Montipora* white syndrome, and (6) *Pocillopora* white band. During our 2006 RAMP cruise, we detected three main types of coral diseases affecting three scleractinian species, including: (1) bleaching on *Montipora* and *Porites*; (2) tissue loss, also affecting colonies of *Montipora* and *Porites*; and 3) *Porites* trematodiasis. Tissue loss on *Porites lobata* was particularly abundant at site PHR-R39. Numerous cases of trematodiasis were encountered primarily at sites PHR-R44 and -R39 on *Porites lobata* and *P. compressa*, respectively. Although the numerical prevalence levels of the above coral syndromes will be estimated at a later date, it is clear, based on the cumulative number of cases encountered at the survey areas, that the incidence of disease in 2006 was, as expected, relatively low (i.e., ca. 1.3 cases per 100 m^2 of reef surveyed; Table G.3.2.3.1).

Equally important as coral diseases, were the 88 cases of compromised health states (CHS) observed (Table G.3.2.3.1). Within this health category, five sets of gross morphologies were identified, including: (1) cyanobacterial overgrowth, affecting colonies of *Porites compressa* at site PHR-R31; (2) diffuse discoloration affecting one colony *Montipora patula*, (3) numerous cases of extensive corallivory because of crown-of-thorns (*Acanthaster planci*) observed on diverse group of sclaractinian species; (4) extensive (>50%) partial mortality with macroalgal overgrowth; and (5) bright pink to maroon pigmentation responses associated with algal overgrowth on colonies of *Porites* spp. *Porites* pigmentation responses were particularly numerous at site PHR-R44. As for the diverse states, the numerical prevalence levels of the above CHS will be estimated at a later date. However, it is clear, based on the cumulative number of cases encountered within the survey areas, that in 2006, their incidence was nearly twice as diseases (i.e., ca. 2.4 cases per 100 m^2 of reef surveyed; Table G. 3.2.3.1).

Tissue samples for histological analyses were procured, including four samples of pigmentation response and one sample of tissue loss on *Porties lobata*. At a future date, histological examination of tissues will be used to confirm specific disease etiology.

Table G.3.2.3.1 Compromised health states of corals.

Type of disease/syndrome	Species	Total # cases
Bleaching	*Montipora capitata*	1
	Porites compressa	3
	Porites lobata	3
Tissue loss	*Montipora capitata*	1
	Porites compressa	1
	Porites lobata	9
Trematodiasis	*Porites compressa*	6
	Porites lobata	25
Compromised health condition		
Cyano-bacterial overgrwoth	*Porites compressa*	2
Discoloration	*Montipora patula*	1
Acanthaster predation	*Pocillopora meandrina*	6
	Leptastrea purpurea	1
	Pocillopora cf. damicornis	15
	Porites compressa	1
	Porites lobata	1
	Porites cf. solida	1
Extensive (>50%) partial mortality and macro-algal overgrowth	*Montipora capitata*	1
	Pocillopora meandrina	13

Type of disease/syndrome	Species	Total # cases
Pigmentation responses with algal overgrowth	*Porites compressa*	2
	Porites lobata	44
Grand Total		**137**

Below, Figure G.3.2.3.1 illustrates the cumulative number of cases of disease and compromised health states enumerated for all survey areas combined at Pearl and Hermes Atoll during the 2006 RAMP cruise. In addition, Figure G.3.2.3.2 presents an itemized breakdown of the taxa exhibiting disease and compromised health states. At a future date, these data will be related to coral colony densities and coral cover in order to numerically estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

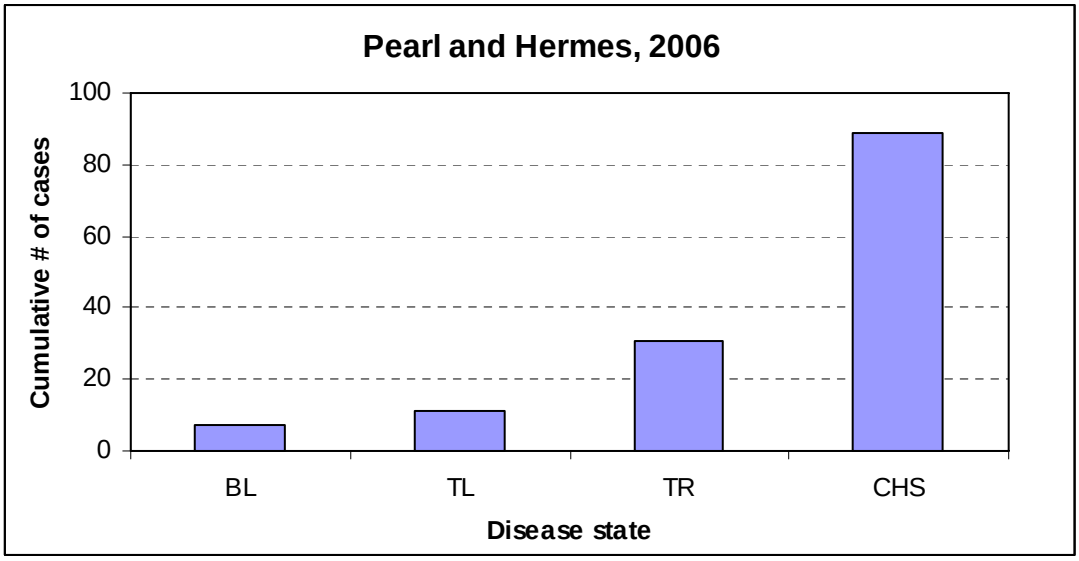

Figure G.3.2.3.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at Pearl and Hermes Atoll during the 2006 RAMP cruise. BL: bleaching; TL: tissue loss; TR: trematodiasis; and CHS: compromised health state, including extensive (>50%) partial mortality, algal overgrowth, predation and other fitness-imperil conditions.

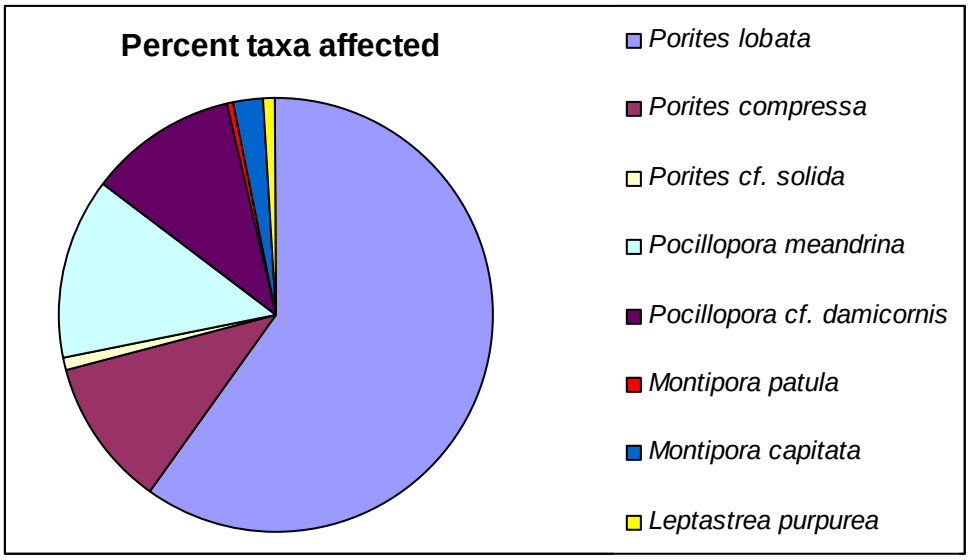

Figure G.3.2.3.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at Pearl and Hermes Atoll, 2006.

G.3.2.4 USFWS permanent coral transects

Eight permanent coral transects were established at Pearl and Hermes prior to the September 2006 visit. Four of these were established at the site of the 2000 grounding of the fishing vessel *Swordman I,* two off the southeast forereef (P&H-1P, -2P) and two off the adjoining backreef at the grounding site (P&H-3P, -4P). Although the writer has not surveyed any of these since establishment in June 2000, others including the 2006 REA team did survey one or more of the backreef sites and will be reporting their results separately. Weather was unfavorable to reach the southeastern forereef sites during the visit. The remaining four permanent transects, originally established in September 2002, were successfully relocated, repaired, and resurveyed. These consist of site P&H-6P, a shallow south lagoon pinnacle slope; P&H-7P, a central lagoon patch reef in the finger coral gardens; P&H-9P in the central floor of the main southern pass of the atoll; and P&H-12P off the southwestern forereef of the atoll.

Coral populations showed smaller mean diameters (7.6 to 11.1 cm) in 2006 compared to their corresponding 2002 values (11.7 to 25.7 cm) at all sites. However, all sites showed higher generic diversity levels in 2006 (3-6 genera/transect) compared to corresponding 2002 values (1-3 genera). The 2006 coral populations also showed larger frequencies at all sites except P&H-9P, varying from 0.4 to19.8 corals/m^2, compared to 2002 levels (1.07 to 4.64 corals/m^2). The small brain coral, *Cyphastrea ocellina* was censused on three of the transects for the first time in 2006, and *Palythoa, Pavona,* and *Psammocora* were all reported for the first time on one transect each.

The three smallest size classes dominated the coral numbers at all 2006 sites except the southern pass site (P&H-9P). Coral populations in the pass were much diminished from their 2002 levels at all size classes. During both the 2002 and 2006 surveys, currents ranged from 2 to 3 knots in the pass, with much suspended sediments. Scour and periodic wave

action may be controlling coral development in the southern pass. At the fingercoral garden site (P&H-7P) corals in the three smallest size classes were more abundant in 2006 compared to 2002 levels for *Porites compressa*, although there was no substantial difference in the larger four size classes. In general, all corals combined were more numerous at the larger size classes at all four sites in 2002. Figures G.3.2.4.1 to G.3.2.4.4 compare size distributions for all corals in 2002 and 2006 at the four permanent coral transect sites.

Figures G.3.2.4.1 to G.3.2.4.4. Size distribution of all corals reported at four permanent transects in 2002 and 2006 (after Maragos 2002 and 2006, unpubl.).

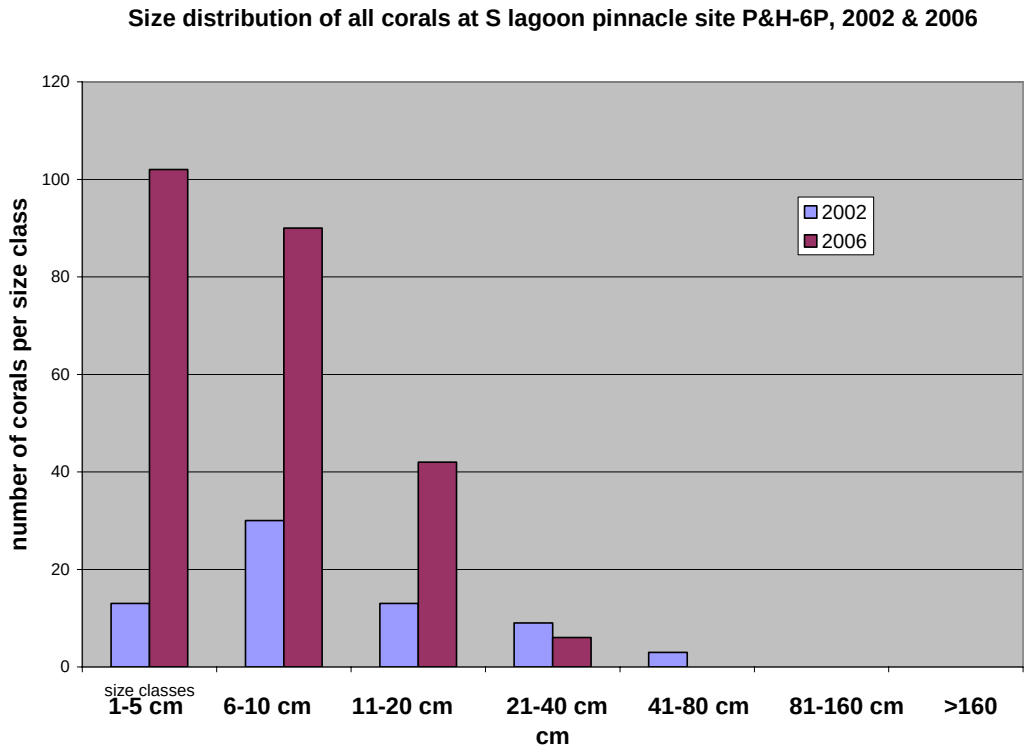

Figure G.3.2.4.1. Size distribution of all corals at Pearl and Hermes Atoll site PHR-6P.

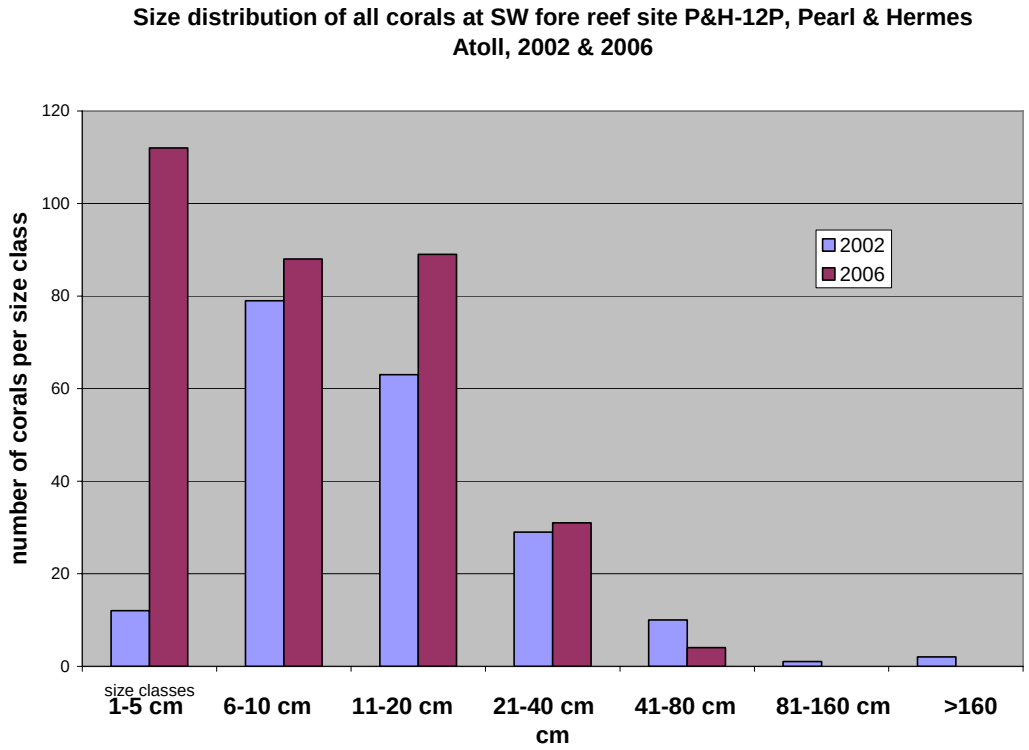

Figure G.3.2.4.2. Size distribution of all corals at Pearl and Hermes Atoll site PHR-12P.

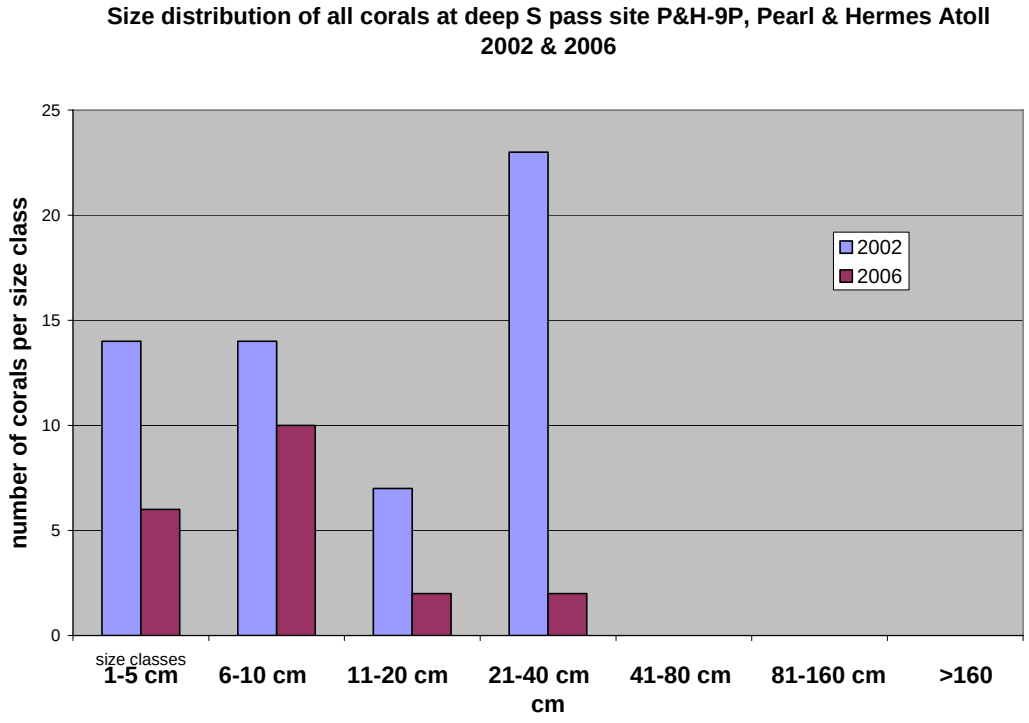

Figure G.3.2.4.3. Size distribution of all corals at Pearl and Hermes Atoll site PHR-9P.

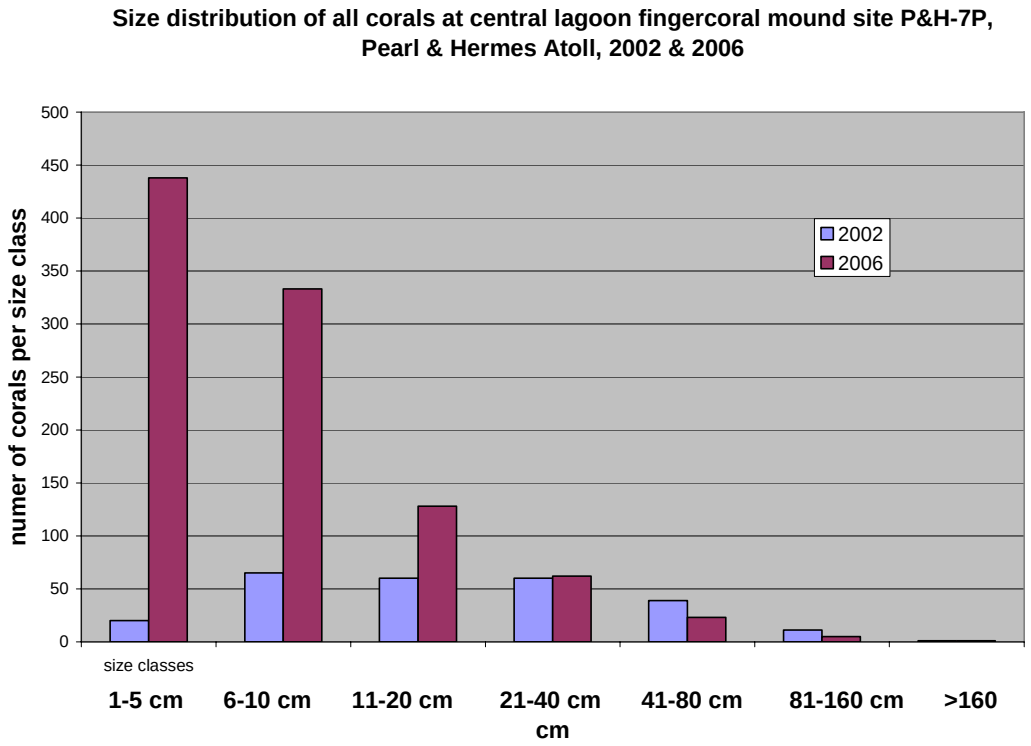

Figure G.3.2.4.4. Size distribution of all corals at Pearl and Hermes Atoll site PHR-7P.

G.3.3 Towed-diver Benthic Surveys

A total of 26 towed-diver surveys covering 67.25 kilometers of habitat were completed along the forereef, backreef, and lagoon areas of Pearl and Hermes Atoll. Along the forereef, bottom complexity ranged from medium-low to medium in the southern and southeastern reefs and varied from medium-high to high along the southwestern, eastern, and northern reefs. The backreef was consistently recorded as medium-low to medium complexity, and the lagoon was recorded as medium-high bottom complexity.

The dominant habitat of the 17 forereef surveys was recorded as spur-and-groove reef, with the exception of the surveys conducted along the northern and southern pavement reefs. Coral cover averaged 6.7%, with noticeable increases of *Pocillopora meandrina* in the southwestern region of the atoll and *Pavona duerdeni* in the northeastern reefs (coral cover averaged 22.3% and 23.0%, respectively). An unusual observation of *Acropora* was recorded along the southeastern forereef (Fig. G.5.2, tow 8), which may be a first observance of the genus at this atoll. Macroalgae cover averaged 33.8%, with the dominant algae species being either *Microdictyon setchellianum* or *Halimeda*. Coralline algae cover remained relatively low, averaging 4.3% of the bottom habitat.

The eight backreef surveys recorded pavement and patch reefs interspersed within sand and rubble fields as the dominant habitat. Coral cover averaged 4.7%, macroalgae

cover averaged 11.6% (mostly *Microdictyon setchellianum* or *Halimeda*), and coralline algae accounted for 4.0% of benthic cover.

A single towed-diver survey was conducted in the lagoon, where coral cover made up 77.5% of the benthic substrate (mostly *Porites compressa*, with *Montipora*, *Pocillopora*, and *Leptastrea* present). Macroalgae and coralline algae cover was 4.6% and 0.6%, respectively.

High numbers of sea urchins were recorded along forereef surveys (average 335/5-minute time segment), especially in the east and southern/southeast reefs (Fig. G.5.2, tows 4, 8, 13 and 14), whereas sea cucumber numbers remained low throughout all forereef surveys (average 6/5-minute time segment). Sea urchin numbers were comparatively much lower on the backreef surveys (average 35/5-minute time segment), while sea cucumbers experienced an increase in comparison with forereef surveys (average 16/5-minute time segment), especially in the northeast (Fig. G.5.2, tow 19). Macroinvertebrate recordings within the lagoon were low, counting only two sea cucumbers during the 50-mimute towed-diver survey. Finally, a total of 123 crown-of-thorns starfish were recorded at Pearl and Hermes, with 121 of the sightings along the forereef. A significant number of these (32) were recorded along the towed-diver survey along the forereef directly west side of the large channel which leads from the open ocean to inside of the atoll (Fig. G.5.2, tow 6).

G.4 Fish

G.4.1 REA Fish Surveys

SPC data

A total of 214 fishes of 26 species were seen in SPC surveys at the 13 Pearl and Hermes sites (16 fishes/dive), and 137 of the fishes (64%) were 50 cm or smaller. There was a greater percentage of fishes larger than 50 cm seen here than at any other site. By far, the most numerous fishes counted in SPCs were *Naso unicornis* (50) and *Caranx ignobilis* (43). Other somewhat abundant species counted were *Aprion virescens* (15), *Melichthys niger.* (14), and *Bodianus bilunulatus* (13).

BLT data

A total of 4005 fish of 94 species were counted at the 13 sites on BLT transects. This reflects a fish density of 0.51 fishes/m^2. By far, the most numerically abundant species was *Thalassoma duperrey* (774 individuals counted). After the saddleback wrasse, a number of planktivorous and herbivorous species were found in high abundances: *Dascyllus albisella* (301 individuals counted), *Scarus psitticus* (259), *Chromis ovalis* (229), *Chromis hanui* (204), *Stegastes fasciolatus* (182), *Abudefduf abdominalis* (167), *Chromis vanderbilti* (145), *Chlorurus sordidus.* (144), *Ctenochaetus strigosus* (111), *Chaetodon miliaris* (107), and *Parupeneus multifasciatus* (106). The size frequencies of all fishes are presented in Figure G.4.1.1.

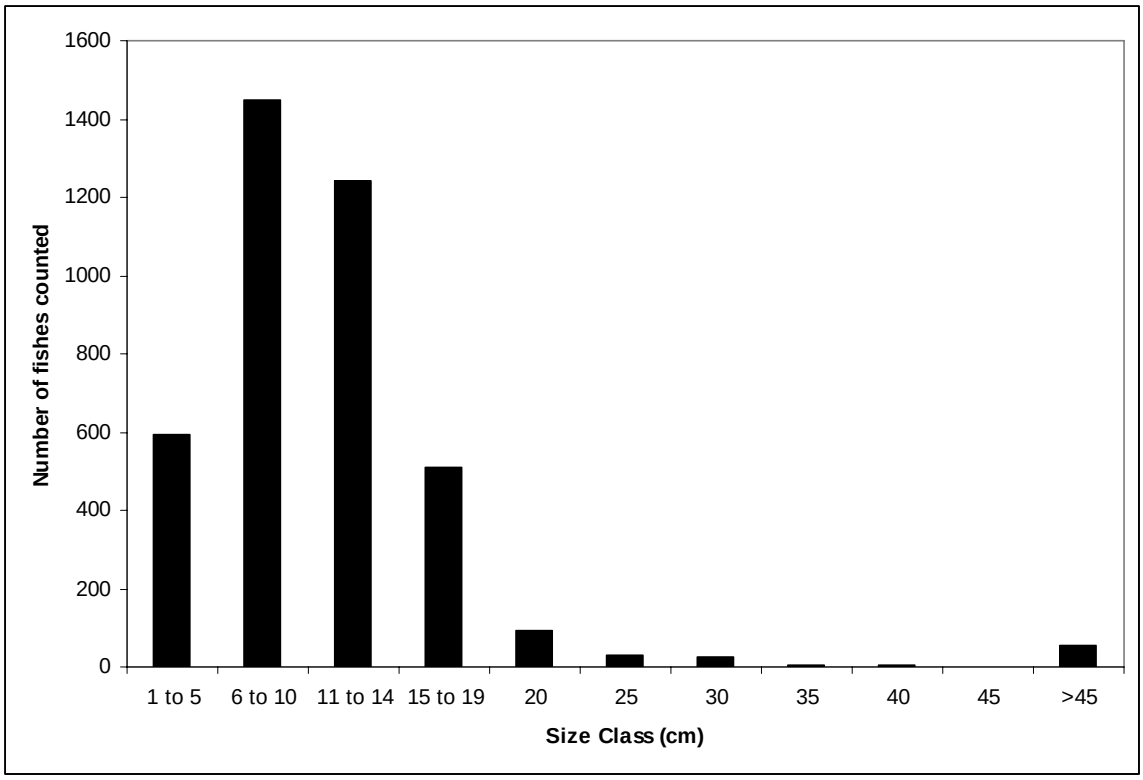

Figure G.4.1.1. Size frequencies of fish at Pearl and Hermes Atoll.

Overall observations:

Overall, Pearl and Hermes Atoll was a study in contrasts. We did a large number of dives where there were exceedingly depauperate fish communities, both in terms of diversity and abundance. On the other hand, we had a few very nice forereef dives with incredible abundance and diversity of fishes. In total, 166 species of fishes were seen at Pearl and Hermes Atoll. This is the highest diversity documented thus far on the cruise.

G.4.2 Towed-diver Fish Surveys

Table H.4.2.1. HI06_11 Towed-Diver Survey Report for Pearl and Hermes Atoll.

			Survey Length				Mean Depth
		N	**Min**	**Max**	**Median**	**Sum**	**Median**
Pearl & Hermes Atoll	**09/12/2006**	6	2.55	3.33	3.06	18.07	-10.95
	09/13/2006	6	1.77	2.34	2.10	12.50	-6.11
	09/14/2006	5	2.26	3.48	2.52	13.57	-11.09
	09/22/2006	5	2.25	3.32	2.71	13.99	-15.70
	09/23/2006	4	2.04	2.66	2.27	9.23	-7.42
	All	26	1.77	3.48	2.53	67.35	-10.61

N = number of surveys conducted.

Survey Length is given in kilometers.

Depth readings are taken at 5 sec intervals during each 50 min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of 24 species of large fishes (>50 cm TL) representing 13 families were observed at Pearl and Hermes Atoll during the survey period (09/12/06–09/14/06 and 9/22/06–9/23/06). The mean number of fishes (all species pooled) observed by divers was 0.312 ha^{-1} and the 22 mostly commonly recorded species are shown in Fig. H.4.2.1. The giant trevally (*Caranx ignobilis*) was the most abundant species observed during the quantitative surveys with a mean number of 4.64 fishes observed per hectare. The smallmouth bonefish (*Albula glossodonta*) was the second most abundant fish species encountered during the survey period with a mean numeric density of 2.18 ha^{-1}. Bonefish (Albulidae) are not frequently encountered in the NWHI and the unusually high numeric density of *A. glossodonta* can be attributed to a large school (n = 100) being observed during a single survey.

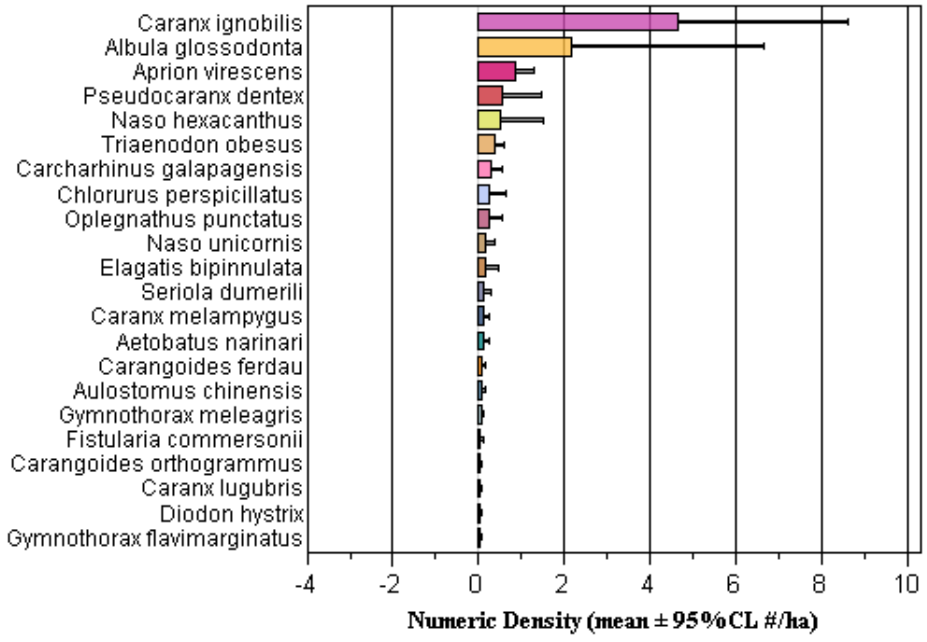

Figure H.4.2.1. The mean numeric density (number of fishes ha^{-1}) of the twenty-two most commonly observed fishes at Pearl and Hermes Atoll during the survey period.

The grand mean biomass density of fishes observed on the shallow-reefs (<30 m) at Pearl and Hermes Atoll during the survey period was 3.88×10^{-3} t ha^{-1}. Apex predators accounted for more than 87% of the total recorded large fish (>50 cm TL) biomass at Pearl and Hermes Atoll (Fig. H.4.2.2). The giant trevally (*Caranx ignobilis*) alone accounted for over 60% of the large fish biomass with a mean biomass density of 7.94×10^{-2} t ha^{-1}. The Galapagos shark (*Carcharhinus galapagensis*) and whitetip reef shark (*Triaenodon obesus*) also contributed to the high biomass observed at Pearl and Hermes yielding biomass density values of 1.69×10^{-2} t ha^{-1} and 0.99×10^{-3} t ha^{-1} respectively.

G.4.3 Shark Receivers

We recovered, downloaded and redeployed 4 receivers (Table 1), and refurbished the ground tackle for these units. The old ground tackle was removed from the reef at all locations.

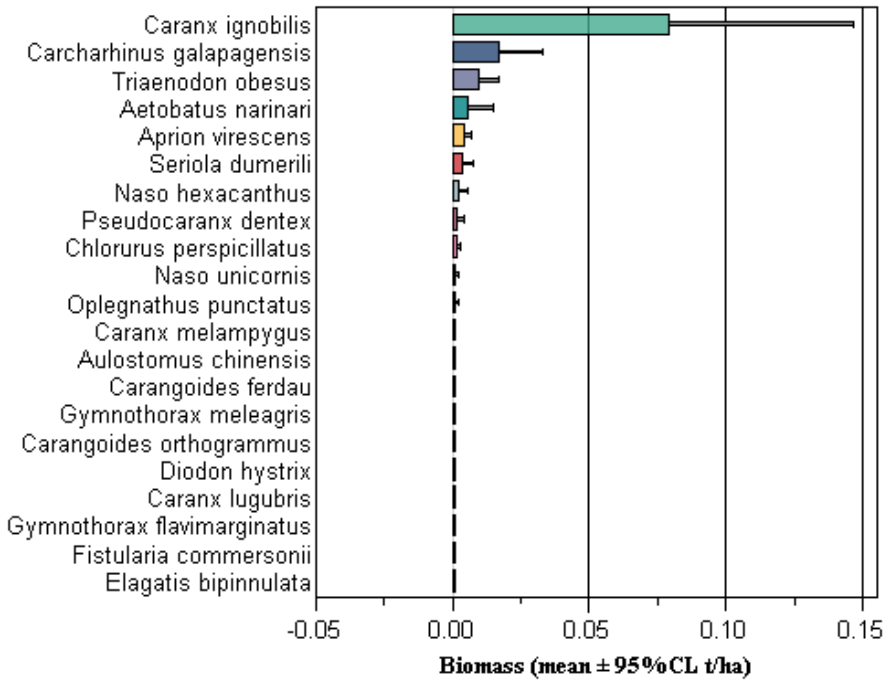

Figure H.4.2.2. The mean biomass (t ha^{-1}) of the twenty-two most commonly observed fishes larger than 50 cm (TL) at Pearl and Hermes Atoll during the survey period.

G.5 Maps

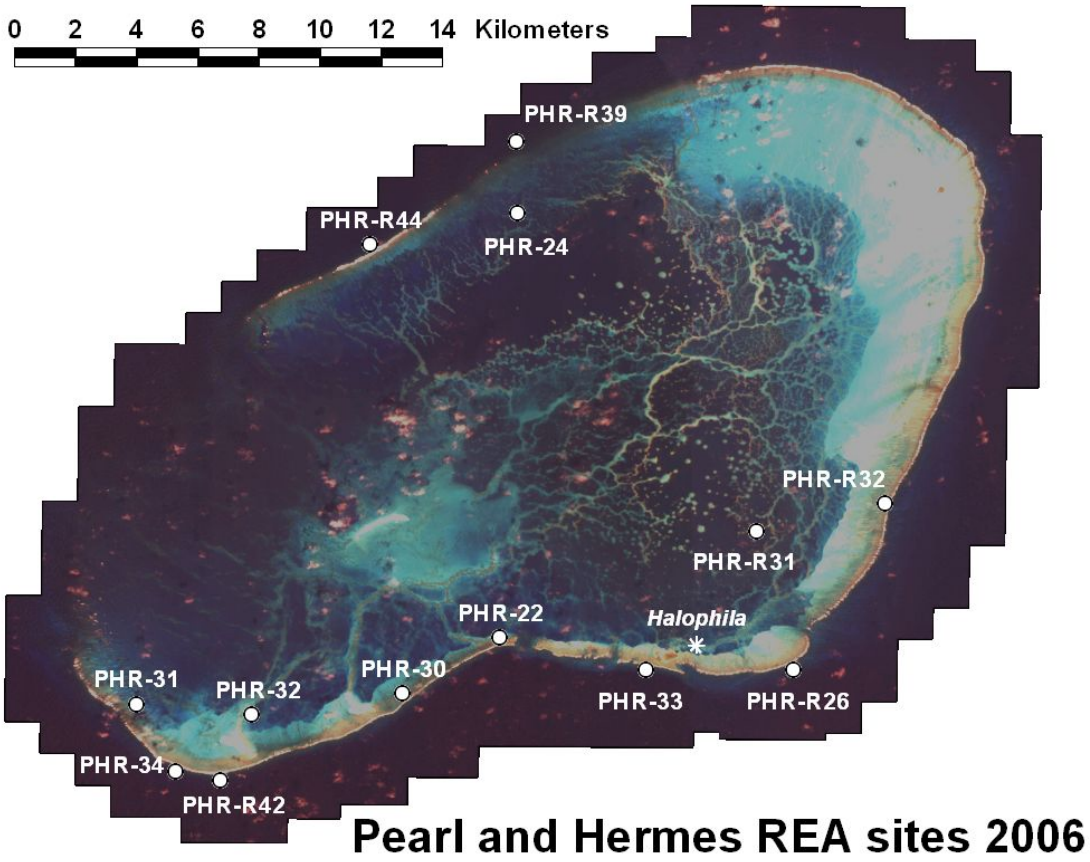

Figure G.5.1. Map showing location of 2006 Rapid Ecological Monitoring (REA) sites at Pearl and Hermes Atoll.

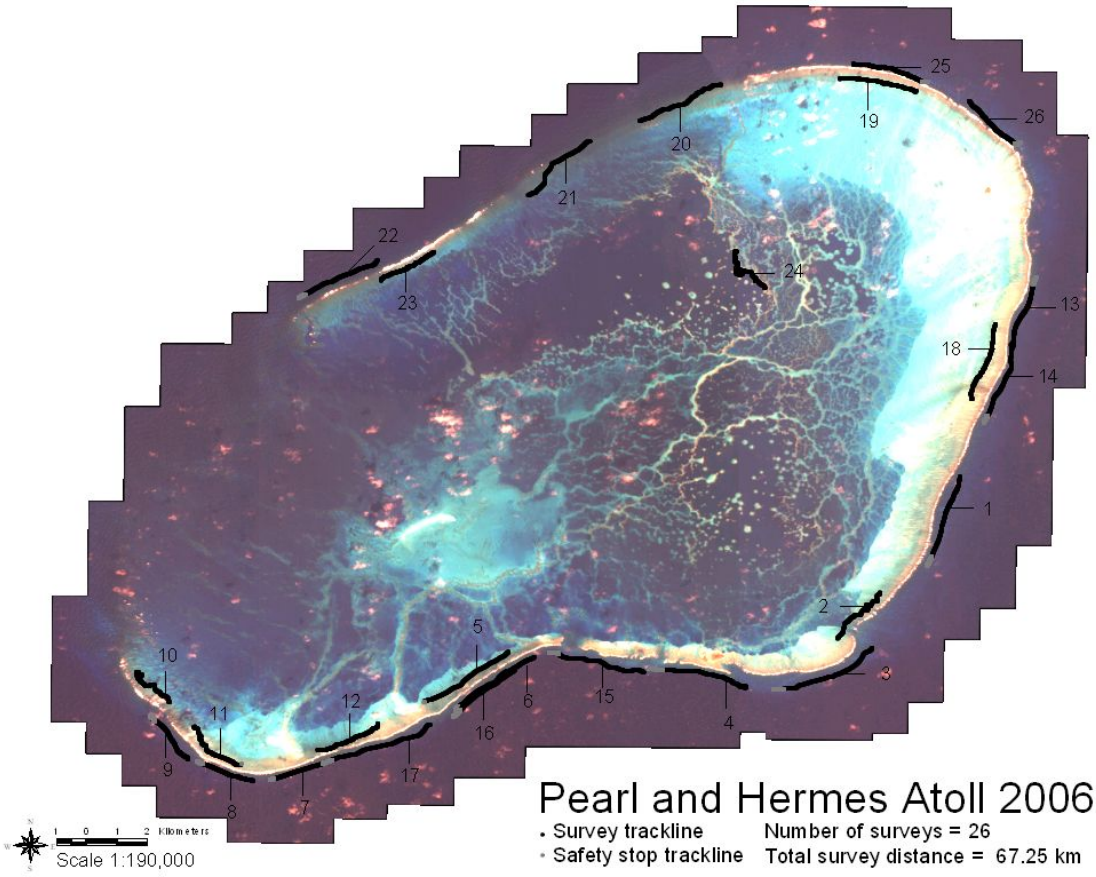

Figure G.5.2. Map showing location of towboard tracks at Pearl and Hermes Atoll.

Appendix H: Kure Atoll

H.1. Oceanography and Water Quality

A total of six instruments were recovered and nine instruments were deployed at Kure Atoll. One Coral Reef Early Warning System (CREWS) buoy and CREWS buoy anchor was removed and replaced (Fig. H.1.1). The addition of two pad eyes on the CREWS buoy anchor will allow for a 6-year anchor deployment eliminating the need to tow in an anchor during the next two RAMP cruise swaps. A sea surface temperature (SST) buoy colocated with the CREWS buoy was also replaced. The existing SST was deployed in 2005 in order to replace a nonfunctioning CREWS buoy. The SST buoy was redeployed in order to ensure a near real-time sea-surface temperature record at the northwesternmost end of the Northwestern Hawaiian Islands (NWHI) Archipelago. Two wave and tide recorders (WTR) were successfully recovered and replaced; one located to the northwest and the other located to the southeast of Kure. The WTRs were both moved to approximately 20-m depths in order to provide for direct comparison of results from both sites. Two subsurface temperature recorders (STR) were recovered; one in shallow backreef habitat on the western side of the atoll and the other on the CREWS buoy anchor. One STR deployed on the northern interior side of the atoll was not recovered and is presumed lost. Five STRs were deployed; three deployments at existing lagoonal locations and two new forereef locations colocated with the WTRs. In addition, an ecological acoustic recorder (EAR) was deployed at the northern end of the atoll in the shallow backreef habitat. The EAR was colocated with one of Carl Meyer's "Top Predator Listening Stations."

Twelve shallow-water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Kure following the 30-m contour. At four of these locations, water sample profiles were performed for a total of eighteen water samples measuring chlorophyll and nutrients levels. In addition, one CTD profile and surface water sample was obtained near the CREWS buoy in the central lagoon. All water samples profiles were conducted concurrently with CTD casts.

Sea surface temperature and salinity data obtained from the CREWS buoy is plotted in Figure H.1.2. Throughout the timeseries, the temperature shows typical seasonal variance with the warmest temperatures (29–30°C) occurring from August to September and cooler temperatures (17–18°C) occurring between February and March (Fig. H.1.2, top panel). Imbedded in the observed seasonal oscillations are high frequency fluctuations, likely owing to diel heating and cooling of lagoonal surface waters. Also observed are sporadic and significant drops in SST on intraseasonal timescales. June 2005 experiences three such drops in SST, the largest of which is observed during the third week in June and shows over a 6 °C change in less than a 3-day period, with half of the temperature change occurring in less than a 12-hour period (Fig. H.1.2, bottom panel).

Salinity fluctuations over the same 2-year period show less seasonal correlation compared to the temperature fluctuations. However, the timeseries shows numerous drops throughout the data set which are not seen in the temperature record (Fig. H.1.2, top panel).

Expanding 1 month of the timeseries, it appears these salinity drops are concurrent with 0.5–1.0 °C drops in temperature (Fig. H.1.2, bottom panel).

Significant wave height obtained from the northwest and southeast sides of Kure from September 2004 to April 2006 appears dominated by large, episodic winter storm events (Fig. H.1.3). The largest event occurs in January 2005, with measured wave heights of over 7 m. These events are observed to be substantially greater at the northwest end of Kure compared to the southeast end as the vast majority of winter swells are generated in the North Pacific by the Aleutian Low and hit the northern side without obstruction.

The observed drops in salinity and concomitant changes in SST (Fig. H.1.2, bottom panel) are likely as a result of rain events causing a dilution of surface salinity values and a cooling of surface temperatures. Kure receives precipitation year round, explaining the prevalence of salinity spikes throughout the 2-year timeseries. The observed 6 °C drop in SST in late June 2005, however, is not as a result of such an event as salinity over this time period remains relatively constant. This drop in temperature is potentially attributed to an anomalous wave event forcing in cooler, well mixed pelagic waters to inside the atoll, resulting in a complete flushing of the warm interior lagoonal waters. Such an event is observed in the wave data as an out-of-season swell with 2.5 m significant wave heights occurring in late June.

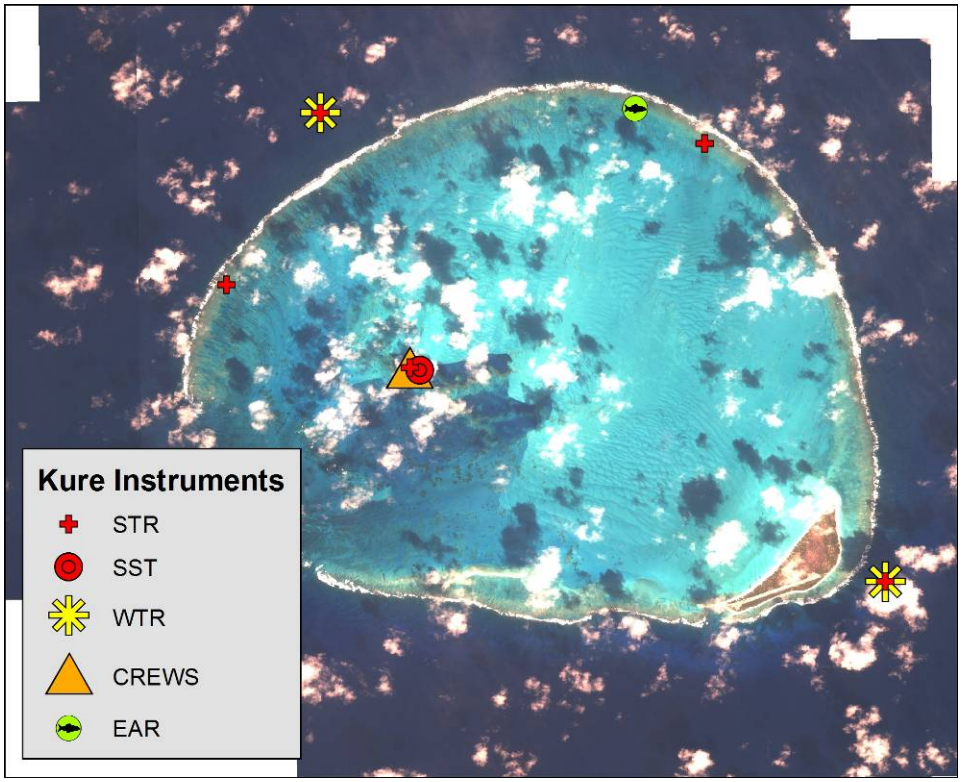

Figure H.1.1. Ikonos satellite image showing CRED oceanographic instrumentation deployed during HI0611.

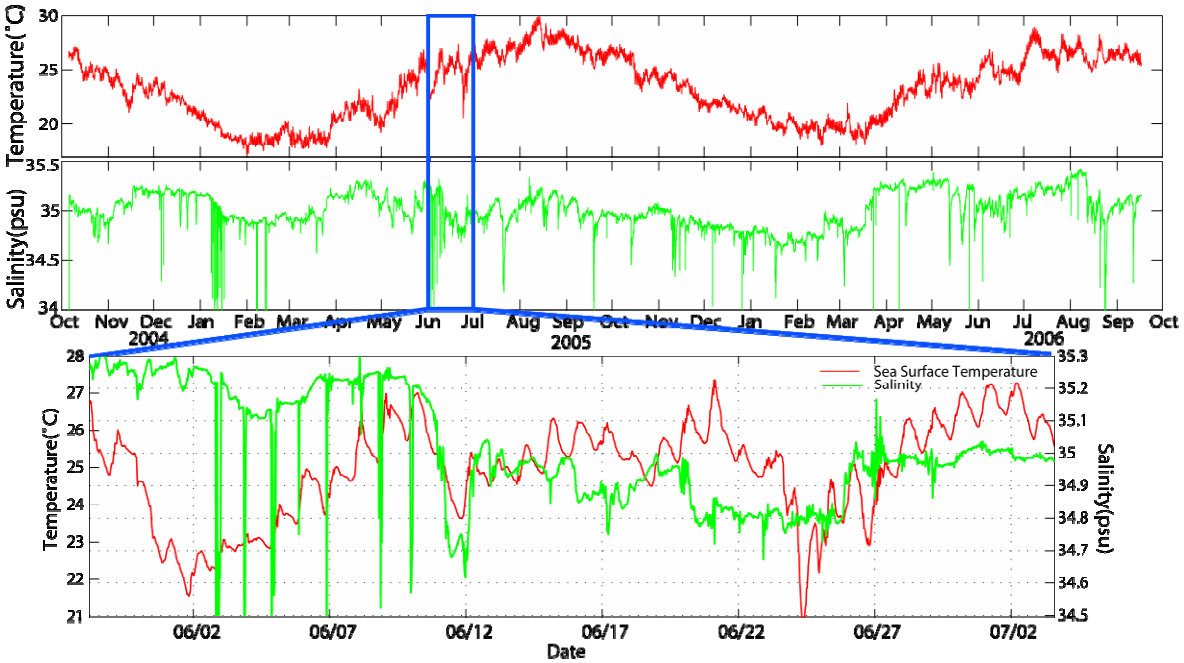

Figure H.1.2. Two-year timeseries of sea surface temperature (°C) and salinity (psu) obtained from the CREWS buoy located in the central lagoon at Kure Atoll (top panel). A 5-week expansion of the temperature and salinity; temperature is on the left vertical axis, salinity is on the right vertical axis. Temperature is plotted in red and salinity is plotted in green.

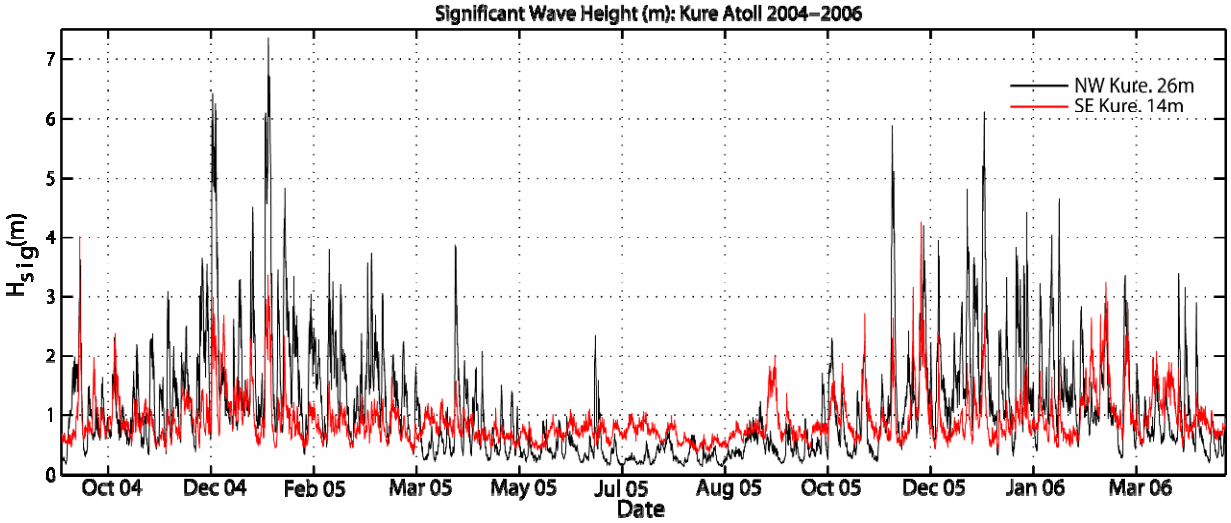

Figure H.1.3. Twenty-month timeseries from September 2004 to April 2006 of significant wave height obtained from two wave and tide recorders located on the northwest (black) and southeast (red) sides of Kure Atoll. Wave heights are measured in meters. Exact instrument locations are shown in Figure H.1.1.

H.2. Rapid Ecological Assessment (REA) Site Descriptions

KUR-12
September 17, 2006

South, fringing forereef; depth range: 9–12.5 m; visibility ~40 m; temperature: 24.5 °C. Spur-and-groove system. New permanent transects (2, 25 m) installed; transects run along top of spur parallel to its axis. This southern forereef site was located along the top of a spur with deep sand channels on either side. Brown algae were very common. Photoquadrats contained turf algae, *Stypopodium flabelliformae*, *Halimeda discoidea*, *Laurencia* sp., *Padina* spp., non-geniculate calcified branched red algae, crustose coralline red algae, *Microdictyon setchellianum*, *Lobophora variegata*, and *Turbinaria ornata*. A species of *Galaxaura* was found during the random swim. Lived coral cover amounted to 11.7%; coral species on point-count transect: *Porites lobata* and *Pocillopora* cf. *meandrina*. Turf algae accounted for >70% of the benthic cover. *Pocillopora meandrina* and moderately fissioned *Porites lobata* were also common. Four anthozoan species (three scleractinians and *Palythoa*) enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Leptastrea purpurea* and *Montipora capitata*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2), 15 cases of trematidiasis on *Porites lobata* were noted; most of these cases were mild. Also, four cases of tissue loss were also noted on colonies of *Porites lobata*; these were focal and associated with pallor. It plausible that these lesions represent predation scars inflicted to the colonies in the recent past. Finally, several cases of predation on *Pocillopora* by *Acanthaster* were noted outside the coral disease survey plot. This site was dominated by small damselfishes, especially *Chromis hanui*, *Dascyllus albisella*, and small wrasses such as *Thalassoma duperrey* and a large number of *Labroides phthirophagous*. The stationary point count (SPC) diver saw primarily *Naso unicornis* and *Chlorurus perspicillatus*. There were several 4–6-ft Galapagos sharks in the distance, and two of the fish divers saw *Epinephelus quernus* in the distance. An unusual sighting of note was a very large *Plectrypops lima*.

KUR-2
September 17, 2006

North, fringing forereef; depth range: 12–13 m; visibility ~25; temperature: 24.5 °C. New permanent transects (2, 25 m) installed along top of spur, running parallel to axis of spur. This northern forereef was dominated by heads of Pocilloporid corals. Inside photoquadrats we recorded turf algae, *Stypopodium flabelliformae*, *Halimeda discoidea*, *Laurencia* sp., *L. galtsoffii*, *Chondrophycus parvipapillatus*, *Dictyopteris repens*, non-geniculate calcified branched red algae, crustose coralline red algae, *Microdictyon setchellianum*, *Lobophora variegata*, *Dictyota friabilis*, and *Turbinaria ornata*. *Dasya iridescens* and a species of *Neomeris* were observed during the random swim. Live coral cover amounted to 25.5%; community dominated by colonies of *Pocillopora* cf *meandrina* and *Porites lobata*. Numerous *Palythoa* colonies consisting of 4–12 polyps; too numerous to count during coral survey. Five anthozoan species (four scleractinians and *Palythoa*)

enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Cyphastrea ocellina* and *Montipora patula*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2), two cases of trematodiasis were observed on *Porites lobata*. In addition, 35 cases of compromised health condition were observed on *Pocillopora*. These involved focal to diffuse pallor, as well as partial mortality and algal overgrowth. This site was dominated by wrasses, particularly *Thalassoma duperrey* and damselfishes, especially *Stegastes fasciolatus*. There were a large number of *Cirripectes vanderbilti* about, and we saw *Exallias brevis* as well. There was not much shelter for fishes along the transect line. The SPC diver saw mostly *Aprion virescens* and large *Chlorurus perspicillatus.* We saw some small Galapagos sharks toward the end of the dive.

KUR-14
September 17, 2006

North, shallow backreef; depth range: 0.9–1.5 m; visibility ~20 m; temperature: 26 °C. Used permanent transects (2, 25 m) installed by Greta Aeby in 2005. Uneven carbonate terrain with moderately low topographic complexity; bioeroded carbonate surfaces interspersed with pavement, rubble, and sand pockets. Carbonate surfaces epiphytized with turf-algae. This shallow, northern backreef site was dominated by algal turf and *Laurencia galtsoffii*. Additionally, *Microdictyon setchellianum*, crustose coralline red algae, *Halimeda velasquezii*, *H. discoidea*, *Lobophora variegata*, and *Turbinaria ornata* were found in photoquadrats. *Stypopodium flabelliformae* was found during the random swim. Live coral cover amounted to 2.9 %; *Pocillopora* cf. *meandrina* and *Porites lobata* were the only scleractinians enumerated along the point-count transect. Other corals present in the general area included: *Leptastrea purpurea*, *Psammocora stellata*, *Letposeris incrustans*, *Montipora capitata*, *Montipora turgescens*, and *Cyphastrea ocellina*. Overall, eight scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Psammocora stellata*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2), 12 cases of trematidiasis were detected on colonies of *Porites lobata*. Most cases were mild to moderate, with some severe ones along transect 2. Additionally, two cases of compromised health condition were observed on *Pocillopora* and *Porites*. These involved focal to diffuse pallor and discoloration, respectively. This shallow site was dominated by wrasses, particularly *Thalassoma duperrey*, and damselfishes, particularly *Stegastes fasciolatus.* There was an unusual abundance of very small *Stethojulis balteata*, and we also saw a small school of ‘iao, *Atherinomoras insularum.*

KUR-33
September 18, 2006

West, fringing backreef; depth range: 13.6–15.9 m; visibility ~15; temperature: 25 °C. Spur-and-groove system; transects run on spine of spur; similar to site KUR-2. New permanent transects (2, 25 m) installed along top of spur, running parallel to axis of spur.

This western forereef site had very poor visibility, and the substrate was dominated by Pocilloporid corals. Inside photoquadrats we found turf algae, *Stypopodium flabelliformae*, *Halimeda discoidea*, *H. velasquezii*, *Sargassum* sp., *Codium* sp., non-geniculate calcified branched red algae, crustose coralline red algae, *Microdictyon setchellianum*, *Lobophora variegata*, and species of *Dictyota*. *Dictyosphaeria cavernosa* was found during the random swim. Live coral cover amounted to nearly 17%; community dominated by colonies of *Pocillopora* cf *meandrina*; this was the only scleractinian enumerated along the point-count transects. The abundance of *Pocillopora meandrina* was similar to site KUR-2 although *Porites lobata* was not as common, and *Palythoa* colonies had more "normal" appearance (i.e., did not consist of 4-12 polyps as was typical and numerous at KUR-2). Heavily bioeroded carbonate. *Pocillopora meandrina* at both sites have different appearance than elsewhere, i.e., branches are straighter, giving colony a more even appearance, suggesting the possibility of a different species. However, close examination reveals considerable variability within individual colonies in branch morphology, with many branches resembling "normal" *P. meandrina*. Would be interesting to have a taxonomist render an opinion. Five anthozoan species (four scleractinian and *Palythoa*) enumerated within 50 m^2 belt transects. Three additional scleractinian species (*Cyphastrea ocellina*, *Psammocora stellata*, and *Montipora capitata*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (150 m^2), 58 cases of compromised health condition were observed on *Pocillopora*. These involved focal to diffuse pallor, as well as partial mortality and algal overgrowth. In addition, another 25 cases of compromised health condition on *Pocillopora* were observed. These involved focal to diffuse pallor, but no partial mortality. This site was characterized by damselfishes, such as *Plectroglyphidodon johnstonianus*, *Stegastes fasciolatus*, *Chromis ovalis*, and the wrasse *Thalassoma duperrey*. The SPC diver saw a variety of large fish through the murky waters, including three large *Seriola dumerlii*, particularly large *Chlorurus perspicillatus*, and quite a few *Aprion virescens* and surgeonfishes. We finally saw *Epinephelus quernus* at this site.

KUR-R36
September 18, 2006

West, shallow backreef; depth range: 1.8–3.9 m; visibility ~15 m; temperature: 26 °C. Uneven carbonate terrain with moderately low topographic complexity; bioeroded carbonate surfaces interspersed with pavement, rubble, and sand pockets. New permanent transects (2, 25 m) installed along “crest” of backreef, ending at shallow wall of *M. capitata* mounds. Carbonate surfaces epiphytized with turf-algae. This shallow backreef bordered a deeper (4.3 m) rubble area. In photoquadrats, we recorded turf algae, *Microdictyon setchellianum*, *Laurencia galtsoffii*, crustose coralline red algae, *Halimeda discoidea*, cyanophytes, *Stypopodium flabelliformae*, *Dictyosphaeria versluysii*, and non-geniculate calcified branched red algae. *Turbinaria ornata* and additional cyanophytes (including one species that resembled large firmly-gelatinous pink cushions) were found during the random swim. Live coral cover amounted to 9.8%; *Pocillopora meandrina*, *Porites lobata*, *Montipora flabellata*, and *Leptastrea purpurea* were the coral species enumerated along the point-count transect. Transect depth range 3–6 feet. Reef crest composed of highly bioeroded carbonate, rubble, sand; *P. meandrina* most common coral on crest. Low coral cover (est. 5%) but high

diversity at this site: 10 scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Pavona duerdeni* and *P. maldivensis*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300m^2), 19 cases of trematidiasis were detected on colonies of *Porites lobata*; most cases were mild to moderate in severity. Additionally, two cases of tissue loss were also observed on *Porites lobata*. This site had lots of juvenile wrasses such as *Coris venusta, Stethojulis balteata,* and *Thalassoma duperrey*. Damselfishes were also abundant, especially *Stegastes fasciolatus* and *Dascyllus albisella*. The SPC diver saw no large fishes at all. Another beautiful shallow reef pavement site.

KUR-17
September 18, 2006

West, southwest; shallow backreef; depth range: 0.9–3.6 m; visibility ~20 m; temperature: 26 °C. Used permanent transects (2, 25 m) installed by Greta Aeby in 2005.). First transect begins next to two very large mounds of *Pavona duerdeni*. Uneven carbonate terrain with moderately low topographic complexity; dead coral surfaces moderately to heavily bioeroded; carbonate pavement epiphytized with turf-algae. Mild to moderate wave and surge action. Photoquadrats contained mostly turf algae, although individuals of *Dictyosphaeria cavernosa*, *Microdictyon setchellianum*, crustose coralline red algae, *Lobophora variegata*, *Halimeda discoidea*, and non-geniculate calcified branched red algae were also recorded. *Caulerpa webbiana* was found during the random swim. Live coral cover amounted to 16.6%; *Montipora capitata*, *Pocillopora meandrina*, and *Montipora flabellata* were the only coral species enumerated along the point-count transect. Other scleractinian corals present in the general area included: *Pavona duerdeni*, *Pavona varians*, *Leptastrea purpurea*, *Porites lobata*, *Psammocora stellata*, and *Cyphastrea ocellina*. Heavily bioeroded carbonate with rubble and sand; *Pocillopora meandrina, P. damicornis* and *Montipora capitata* most common corals along belt transect, with numerous shallow mounds of *M. capitata* in area. Good coral diversity: eight scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Pavona duerdeni* and *Porites evermanni*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300m^2), 12 cases of trematidiasis were detected on colonies of *Porites lobata*; most cases were mild to moderate in severity. Additionally, one case of tissue loss was also observed on *Porites lobata*. This site was dominated by wrasses and damselfishes, particularly *Thalassoma duperrey, Stegastes fasciolatus,* and *Chromis vanderbilti.* The SPC diver saw predominantly *Chlorurus perspicillatus.* Unusual sightings included *Cheilio inermis* and a few large *Kuhlia sandvicensis.*

KUR-18
September 19, 2006

Central lagoon; shallow patch reef; depth range: 3.7 –8.8 m; visibility ~15 m; temperature: 26 °C. New permanent transects (2, 25 m) installed adjacent to CREWS buoy slope (~45^{o}) of *Porites compressa* patch reef, extending down to sandy bottom. Patch reef; transects run alongside slope. Amongst coral, *Microdictyon setchellianum* and turf algae were extremely abundant. We also recorded *Halimeda discoidea, Lobophora variegata, Dictysphaeria cavernosa, D. versluysii, Peyssonnelia* sp., crustose coralline red algae, *Padina* sp., and cyanophytes within our photoquadrats. *Caulerpa webbiana, C. racemosa,* and *Boodlea composita* were found during the random swim. Live coral cover amounted to nearly 19.6%; community dominated by *Porites compressa* with areas of sand and rubble; the only scleractinian enumerated along the point-count transects. Abundant *Microdictyon*. Moderate coral cover but low diversity: four scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects. Following the dive survey, a random snorkel was conducted to videotape the benthos on the shallow (1-5 feet) reef crest, as this was a site of substantial coral bleaching in 2002 with a consequent phase shift from coral to algal cover. *Porites compressa* appears to be repopulating the shallow crest, along with *Pocillopora damicornis*. All observed *P. meandrina* heads were dead and covered with coralline algae. No montiporids observed. Reef crest currently primarily composed of *P. compressa*, algae, and rubble.

Coral disease and health assessment: Within the survey plot (300 m^2), 12 cases of trematodiasis were observed on *Poirtes compressa*. Site 18 was a compressa bed that was dominated by wrasses such as *Thalassoma ballieui* and *Thalassoma duperrey,* and of course *Stegastes fasciolatus.* We saw a fair number of parrotfish as well, and there were schools of small goatfishes *Mulloidichthys vanicolensis* and *Mulloidichthys vanicolensis*. There were a large number of very small parrotfish recruits. SPC diver saw mainly *Naso unicornis* and *Thalassoma ballieui.*

KUR-9
September 19, 2006

Central lagoon; shallow patch reef; depth range: 3.4–6.7 m; visibility ~15 m; temperature: 26 °C. New permanent transects (2, 25 m) installed. Patch reef; transects run alongside slope. Carbonate surfaces and rubble heavily colonized by marcoalgae and epiphytized with turf-algae. Heavily eroded, *Microdictyon*-covered carbonate with large patches of rubble and sand. Not to complain, but this was the most non-memorable reef we have ever surveyed. Almost no fish or coral. The benthic substrate was dominated by a carpet of heavily epiphytized blades of *Microdictyon setchellianum.* Additionally, turf algae, species of *Dictyota, Stypopodium flabelliformae,* crustose coralline red algae, *Lobophora variegata,* non-geniculate calcified branched red algae, species of *Padina*, *Dasya iridescens*, *Halimeda discoidea*, *Dictyosphaeria versluysii*, and cyanophytes were found. Low live coral cover amounted to 3.9%. *Pocillopora damicornis* and *P. meandrina* were most common corals. Five scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300m^2), two cases of tissue loss were detected on colonies of *Pocillopora*. Additionally, 19 cases of compromised health condition on Pocillopora, involving partial mortality and algal overgrowth. Site 9 was dominated by wrasses such as *Thalassoma ballieui* and *Thalassoma duperrey,* and of course *Stegastes fasciolatus.* SPC diver saw some large parrotfish, both *Chlorurus perspicillatus* and *Chlorurus sordidus*. There were a lot of scorpionfish in the holes in this algae-covered site.

KUR-R35
September 19, 2006

South; shallow backreef; depth range: 3.6–4.5 m; visibility ~15 m; temperature: 26 °C. New permanent transects (2, 25 m) installed. Moderately-eroded carbonate, rubble, and sand. During a qualitative survey, the following algae were recorded: turf algae, *Microdictyon setchellianum,* species of *Dictyota*, *Stypopodium flabelliformae,* crustose coralline red algae, non-geniculate calcified branched red algae, species of *Padina*, *Halimeda discoidea, Turbinaria ornata, Spyridea filamentosa*, species of *Chondria, Sargassum, Codium, Peyssonnelia,* and cyanophytes. Low coral cover amounted to 4.9%. *P. meandrina* most common coral. Numerous large, symmetrical (40-55cm) *P. meandrina* heads. Four scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Porites lobata, Psammocora stellata*) observed in larger area outside belt transects. *Pocillopora meandrin* was the only coral species enumerated along the point-count transect.

Coral disease and health assessment: Within the survey plot (300 m^2), no coral diseases were observed. However, five cases of compromised health condition on *Pocillopora* were detected, involving partial mortality and algal overgrowth. Site 35 was dominated by wrasses such as *Thalassoma ballieui* and *Thalassoma duperrey,* and of course *Stegastes fasciolatus.* This site had the worst fish abundance of all, and that's a bold statement. SPC diver saw nothing on three of four replicates, just two *Bodianus bilunulatus* on the last one.

H.3. Benthic Environment

H.3.1. Algae

Quantitative algal surveys were conducted at nine sites on the forereef, backreef, and lagoonal locations around Kure Atoll (KUR-12, KUR-2, KUR-14, KUR-R-33, KUR-R-36, KUR-17, KUR-18, KUR-9, KUR-R-35). The sites located in the south and north fringing forereef were characterized by spur-and-groove systems, with transects set on the top of a spur with deep sand channels on either side. As noted in past sampling years, brown algae were common at most of the sites sampled. Species included *Stypopodium flabelliformae, Turbinaria ornata, Lobophora variegata,* and species of *Dictyota* and *Padina*. A species of *Dictyopteris* was also found at one of the sites. Other algae recorded at many sites included non-geniculate calcified branched red algae, *Microdictyon setchellianum, Dictyosphaeria cavernosa, Halimeda discoidea, Boodlea composita* and species of *Caulepa.* Overall, 10

species of green algae, 9 species of red algae, and 7 species of brown algae were collected. In addition, microscopic examination of epiphytes will increase the number of species collected substantially.

Table H.3.1.1: Algal genera or functional groups recorded in photoquadrats at Kure Atoll. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	KUR-12	KUR-2	KUR-14	KUR-R-33	KUR-R-36	KUR-17	KUR-18	KUR-9	KUR-R-35
GREEN ALGAE									
Codium	*0.0*	*0.0*	*0.0*	*33.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**3.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Dictyosphaeria	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*8.3*	*58.3*	*8.3*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**5.0**	**2.0**	**3.9**	**5.0**	**0.0**
Halimeda	*41.7*	*8.3*	*16.7*	*75.0*	*25.0*	*8.3*	*16.7*	*8.3*	*0.0*
	5.0	**5.0**	**4.5**	**4.2**	**3.7**	**2.0**	**5.0**	**6.0**	**0.0**
Microdictyon	*75.0*	*50.0*	*58.3*	*41.7*	*75.0*	*16.7*	*75.0*	*100.0*	*0.0*
	3.1	**2.3**	**2.4**	**2.4**	**2.6**	**2.0**	**1.8**	**1.6**	**0.0**
RED ALGAE									
Non-geniculate calcified branched red algae	*50.0*	*33.3*	*16.7*	*16.7*	*16.7*	*8.3*	*0.0*	*25.0*	*0.0*
	4.8	**2.8**	**3.0**	**4.5**	**4.0**	**3.0**	**0.0**	**4.0**	**0.0**
Chondrophycus	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
crustose coralline algae	*16.7*	*0.0*	*58.3*	*83.3*	*91.7*	*0.0*	*25.0*	*75.0*	*0.0*
	5.0	**0.0**	**3.1**	**2.8**	**2.5**	**0.0**	**2.7**	**3.2**	**0.0**
Dasya	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.5**	**0.0**
Laurencia	*58.3*	*83.3*	*75.0*	*0.0*	*33.3*	*0.0*	*0.0*	*0.0*	*0.0*
	4.3	**3.5**	**2.4**	**0.0**	**3.8**	**0.0**	**0.0**	**0.0**	**0.0**
Peysonnellia	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*25.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**0.0**	**0.0**
BROWN ALGAE									
Dictyota	*0.0*	*8.3*	*0.0*	*41.7*	*0.0*	*0.0*	*0.0*	*25.0*	*0.0*
	0.0	**4.0**	**0.0**	**3.8**	**0.0**	**0.0**	**0.0**	**3.3**	**0.0**
Dictyopteris	*0.0*	*8.3*	*0.0*	**0.0**	**0.0**	**0.0**	*0.0*	*0.0*	*0.0*
	0.0	**6.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

	KUR-12	KUR-2	KUR-14	KUR-R-33	KUR-R-36	KUR-17	KUR-18	KUR-9	KUR-R-35
Lobophora	*83.3*	*25.0*	*25.0*	*58.3*	*0.0*	*25.0*	*8.3*	*16.7*	*0.0*
	2.8	**2.7**	**3.7**	**4.3**	**0.0**	**3.7**	**3.0**	**4.0**	**0.0**
Padina	*33.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*8.3*	*0.0*
	5.3	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.0**	**5.0**	**0.0**
Sargassum	*0.0*	*0.0*	*0.0*	*25.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Stypopodium	*100.0*	*25.0*	*0.0*	*25.0*	*8.3*	*0.0*	*0.0*	*50.0*	*0.0*
	3.1	**3.3**	**0.0**	**5.0**	**3.0**	**0.0**	**0.0**	**5.0**	**0.0**
Turbinaria	**8.3**	**0.0**	**8.3**	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	7.0	*0.0*	*5.0*	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
FUNCTIONAL GROUPS									
turf algae	*100.0*	*100*	*100*	*100.0*	*100*	*91.66*	*100.0*	*100*	*0*
	1.0	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.8**	**1.3**	**0.0**
cyanophytes	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*25.0*	*8.3*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**2.0**	**0.0**	**5.0**	**5.0**	**0.0**

Table H.3.1.2: Putative algal species found at Kure Atoll. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis.

List of putative macroalgal species collected
(one sample per site)

	KUR-12	KUR-2	KUR-14	KUR-R-33	KUR-R-36	KUR-17	KUR-18	KUR-9	KUR-R-35
GREEN ALGAE									
Boodlea composita							X		
Caulerpa racemosa							X		
Caulerpa webbiana						X	X		
Codium spp.				X					X
Dictyosphaeria versluysii					X		X	X	
Dictyosphaeria cavernosa				X		X	X		
Halimeda discoidea	X	X	X	X	X	X	X	X	X
Halimeda velasquezii			X	X					
Microdictyon setchellianum	X	X	X	X	X	X	X	X	X
Neomeris sp.		X							
RED ALGAE									
Non-geniculate calcified branched red algae	X	X	X	X	X	X		X	X
Chondria sp.									X
Chondrophycus parvipapillatus		X							
Dasya iridescens		X						X	
Galaxaura spp	X								
Laurencia sp.	X	X							
Laurencia gattsoffii		X	X		X				
Peysonnellia spp.							X		X
Spyridia filamentosa									X
BROWN ALGAE									
Dictyota spp.		X		X				X	X
Dictyopteris repens		X							
Lobophora variegata	X	X	X	X		X	X	X	
Padina spp.	X						X	X	X
Sargassum sp.				X					X
Stypododium flabelliformae	X	X	X	X	X			X	X
Turbinaria ornata	X	X	X		X				X

H.3.2. Corals

Coral REA surveys were conducted at all nine sites that were selected by CRED and partners in 2003 for long-term monitoring. Of these nine sites, all were most recently surveyed by CRED in October 2004, and six were surveyed by the NWHI Coral Reef Ecosystem Reserve in September 2005. At two of these long-term monitoring sites (KUR-14 and KUR-17), permanent transect markers had been installed by Dr. Greta Aeby in 2005 and were used by survey teams this year to guide deployment of transect lines (2, 25 m per site). Permanent transect markers were installed at the remaining seven sites this year along the first two transects by members of the REA fish team with the intention of reducing error because of spatial imprecision on future surveys. Global Positioning System (GPS) site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded after descending, in order to facilitate relocating the markers on future surveys.

H.3.2.1 Coral populations

A total of 1929 colonies belonging to 13 anthozoan taxa were enumerated within belt transects enclosing 450 m^2 benthic substrate (Table H.3.2.1). The most frequently occurring taxa were *Pocillopora meandrina, Porites lobata*, and *Pocillopora damicornis*. Three additional scleractinian taxa not seen within belt transects were observed within the larger survey area surrounding the transect belts (*Montipora patula, Pavona duerdeni,* and *Pavona maldivensis*).

Table H.3.2.1. Number of anthozoans enumerated within belt transects at Kure Atoll during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Taxon	# of colonies	Percent of total
Acropora cytherea	0	0.0
Acropora valida	0	0.0
Acropora humilis	0	0.0
Montipora capitata	53	2.7
Montipora patula	0	0.0
Montipora verilli	0	0.0
Montipora flabellata	37	1.9
Montipora turgescens	0	0.0
Montipora incrassata	0	0.0
Pavona duerdeni	0	0.0
Pavona varians	4	0.2
Cyphastrea ocellina	29	1.5
Leptastrea purpurea	70	3.6
Fungia scutaria	0	0.0
Pocillopora damicornis	259	**13.4**
Pocillopora eydouxi	0	0.0
Pocillopora ligulata	10	0.5
Pocillopora meandrina	1010	**52.4**
Porites brighami	0	0.0
Porites compressa	104	5.4
Porites evermanni	1	0.1

Taxon	# of colonies	Percent of total
Porites lobata	315	**16.3**
Psammocora stellata	21	1.1
Palythoa sp.	16	0.8
Zoanthus pacifica	0	0.0
Total # colonies	1929	100.0
Area surveyed, m^2	450	

A size class distribution of all corals enumerated within belt transects is shown in Figure H.3.2.1. Of the 1929 colonies whose maximum diameter was visually estimated, 42.5% had a maximum diameter <10 cm, and 2.1% had a maximum diameter >40 cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003–2004 surveys.

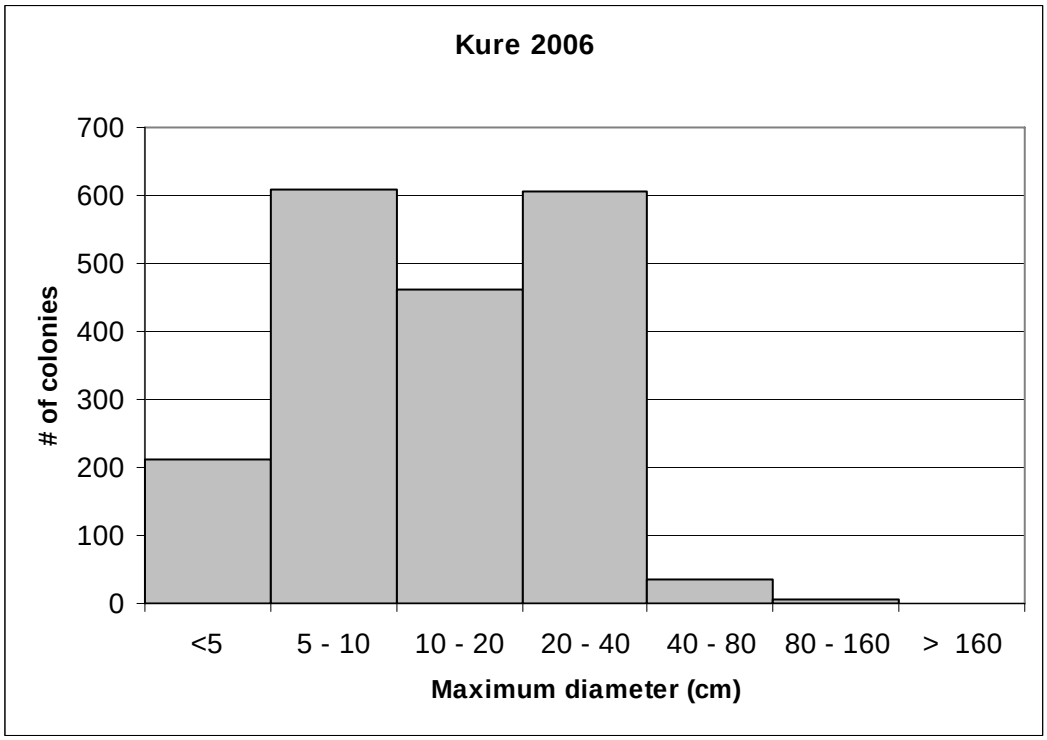

Figure H.3.2.1. Size class distribution of 1929 coral colonies enumerated within belt transects at Kure in 2006.

H.3.2.2. Percent benthic cover

Percent benthic cover surveys at Kure Aroll were conducted in congruency with the fish, coral population, and algae REA surveys, at nine sites around Kure Atoll. These were accomplished along the north, south, and west portions of the atoll, as well as the three sites in the central lagoon. . Point-count, percent liver coral cover surveys were conducted along a total of 918 meters of coral reef communities along the outer forereefs, the inner backreefs, and the patch reefs in the central lagoon. These surveys indicated that that mean coral cover for all sites combined was over 13%, with *pocillopora* cf. *meandrina lobata* alone accounting for over 56% of all scleractinian coral taxa enumerated along the transect lines; *Pocillopora*

exhibited moderately high percent cover along the north and west forereef sites. *Porites*, was second in order of importance; this genus was particularly abundant at site KUR-18 in the central lagoon. Turf algae and macroalgae colonizing the dead coral surfaces, the carbonate pavement, and rubble, also accounted for a substantial portion of the biological benthos (57%). Table H.3.2.2.1 provides a complete list of percent cover of the different benthic elements enumerated using the point-intercept methodology at Kure Atoll. Figure H.3.2.2.1 illustrates the contribution of the different scledractinain taxa to the total percent live coral cover.

Table H.3.2.2.1 Percent cover of the benthic elements at Kure Atoll using the point-intercept method during the 2006 REA activities.

Species	Total	% cover
Cyphastrea ocellina	1	0.1
Pocillopora meandrina	68	7.4
Porites compressa	20	2.2
Porites lobata	19	2.1
Leptastrea purpurea	2	0.2
Montipora capitata	8	0.9
Montipora flabellata	3	0.3
Halimeda	2	0.2
Macro-algae	182	19.8
Coralline algae	18	2.0
Pavement/cca	3	0.3
Pavement/Lobo	1	0.1
Pavement/turf	345	37.6
Rubble	24	2.6
Rubble/cca	1	0.1
Rubble/turf	66	7.2
Sand	77	8.4
Sand/turf	11	1.2
Dead	1	0.1
Dead/cca	15	1.6
Dead/lobo	2	0.2
Dead/turf	44	4.8
Other	5	0.5
Grand Total	918	

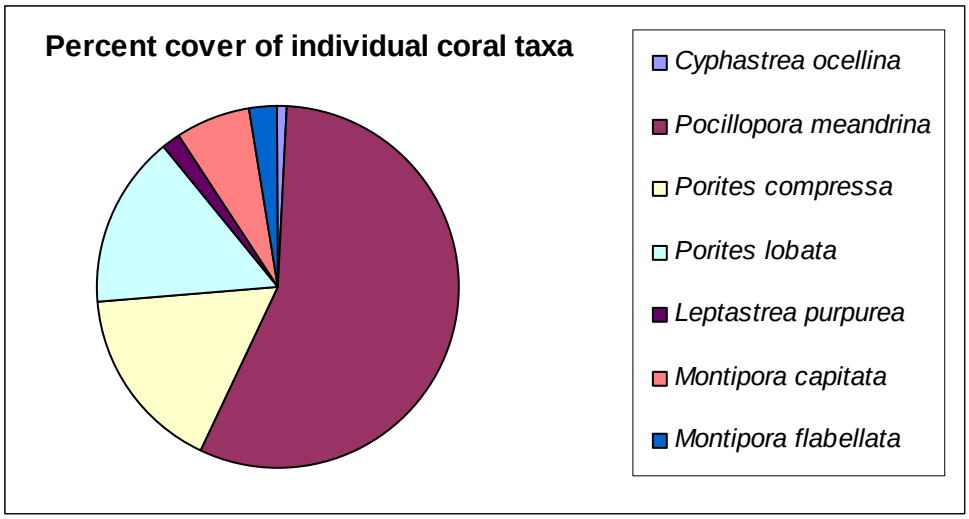

Figure H.3.2.2.1. Percent contribution of the different taxa to the total live coral cover.

H.3.2.3. Coral disease

The coral disease REA surveyed a total of 2550 m^2 at nine different sites during the visit to Kure Atoll. During the HI0401 2004 Reef Assessment and Monitoring Program (RAMP) cruise, Dr. Greta Aeby reported the occurrence of six different coral diseases at Kure Atoll (i.e., *Porites* trematoidiasis, *Porites* tissue loss, *Porites* dark tissue thinning, *Porites* growth anomaly, *Montipora* tissue loss, and *Montipora* white spots). In contrast, during our 2006 RAMP, only two main types of afflictions to scleractinian corals were detected at Kure; these include trematodiasis and tissue loss, both on corals of the genus *Porites*. Equally important, were the many (71) cases of compromised health state observed. Grossly, colonies exhibited varying degrees of predation, partial mortality, discoloration (other than bleaching), and algal overgrowth (particularly macroalgae and crustose coralline algae). Pocilloporid corals at sites KUR-2 and KUR-22 were the most affected, exhibiting an estimated 10% prevalence. A total of three tissue samples were procured for histological analyses. At a future date, histological examination of tissues will be used to confirm specific disease etiology.

Table H.3.2.3.1: Complete percent cover of various benthic elements.

Type of disease	Species	Total
Tissue loss	*Pocillopora*	2
	Porites lobata	7
Trematodiasis	*Porites compressa*	12
	Porites lobata	61
Compromised health state		
Discoloration	*Pocillopora*	39
	Porites lobata	4
Predation	*Pocillopora*	1
Partial mortality	*Pocillopora*	24

Type of disease	Species	Total
Pigmentation response	*Porites lobata*	3

Figure H.3.2.3.1 illustrates the cumulative number of cases of disease conditions enumerated for all survey areas combined at Kure Atoll during the 2006 RAMP cruise. In addition, Figure H.3.2.3.2 illustrates an itemized breakdown of the taxa exhibiting disease and compromised health states. At a future date, these data will be related to coral colony densities and coral cover in order to estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

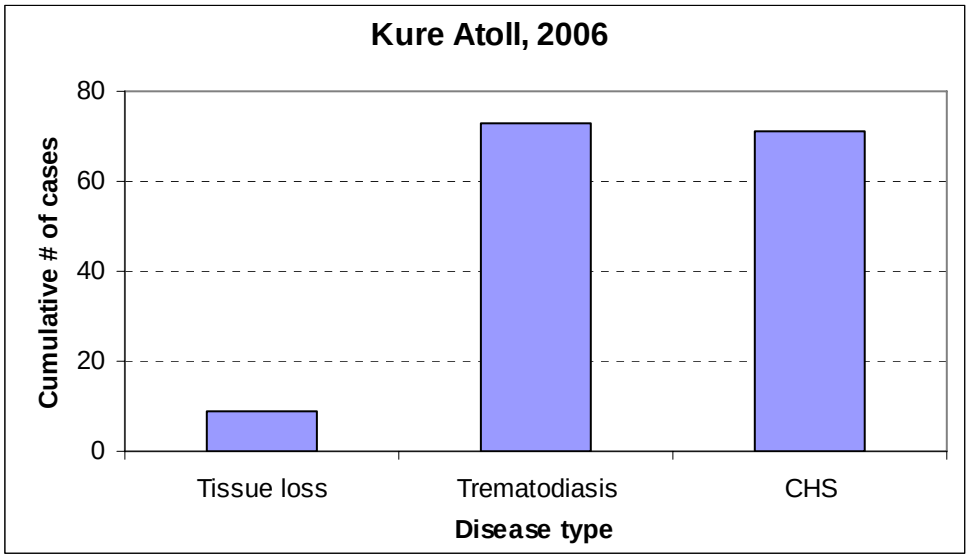

Figure H.3.2.3.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at Kure Atoll during the 2006 RAMP cruise. CHS: compromised health state.

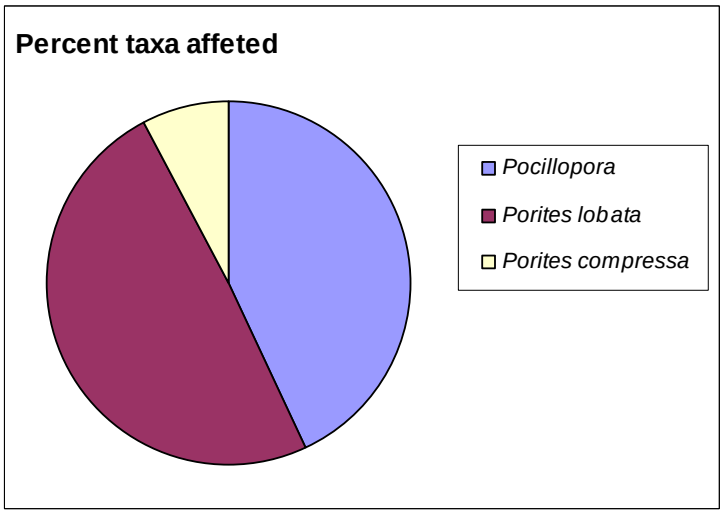

Figure H.3.2.3.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at Kure Atoll, 2006.

H.3.2.4 U.S. Fish and Wildlife Service (USFWS) permanent coral transects

No USFWS permanent coral transects exist at Kure Atoll.

H.3.3 Towed-diver Benthic Surveys

A total of 13 towed-diver surveys over 29.3 kilometers of habitat were completed along the forereef, backreef, channel, and lagoon areas of Kure Atoll. Bottom complexity ranged from medium to medium-high along the forereef, medium to medium-low along the backreef and medium in the lagoon. The channel exhibited characteristics of both forereef and backreef environments, with the bottom habitat ranging from medium-high complexity.

All seven forereef surveys recorded spur and groove as the dominant habitat. Coral cover averaged 17.3% with a noticeable increase in *Pocillopora* (*meandrina*) in the north and northwest region of the atoll. An increase in coral stress (in *pocilloporas*) was recorded in these same areas, affecting up to 35% of coral observed. An unusual observation was that many of these colonies appeared only partially stressed (i.e., a proportion of the colony would appear healthy: pale/stressed). Macroalgae cover averaged 10.9%, with the dominant algae species being *Microdictyon setchellianum* and coralline algae cover averaging 5.9%.

The four backreef surveys recorded pavement and patch reefs interspersed within sand and rubble fields. Coral cover averaged 5.5%, with an exception of the *Montipora* gardens of the northwest (Fig. H.5.2, tow #11), where the average coral cover during one survey was recorded at 32% and as high as 75% in one time segment. Macroalgae (mostly *Halimeda* species and *Microdictyon setchellianum*) and coralline algae accounted for 18.5% and 2.1% of benthic cover, respectively.

A single towboard survey was conducted in the lagoon, where *Porites compressa* and macroalgae dominated the benthos. Coral cover was 12.0%, macroalgae was 23.0%, and coralline algae 1.8%.

High numbers of sea urchins were recorded along forereef surveys (average 608/5-minute time segment), especially in the north (Fig. H.5.2, tow #9; all time segments recording >1000 sea urchins) and southeast. Sea cucumber numbers remained low during forereef surveys (average 12 individuals/5-minute time segment). Sea urchins were comparatively lower on the backreef surveys, with small localized increases never exceeding 375 urchins (three time segments shown in Fig. H.5.2, tow #11). The backreef surveys noted higher numbers of sea cucumbers, with localized increases also noted in the northeast backreef (Fig. H.5.2, tow #11; 1st two-time segments recorded 175 sea cucumbers). Sea urchin and sea cucumber numbers remained comparatively low during the lagoon survey and showed an interesting trend during the channel survey as the divers progressed from forereef to backreef environments (sea urchin counts decreased; sea cucumber counts increased). Finally, only six crown-of-thorns starfish were noted during all towed-diver surveys at Kure.

H.4 Fish

H.4.1 REA Fish Surveys

SPC data

A total of 170 fishes of 24 species were seen in SPC surveys at the nine Kure sites (19 fishes/dive), and 163 of the fishes (96%) were 50 cm or smaller. There was an obvious paucity of large fishes in general, and large predators in particular (only six uku and one ulua counted on all nine dives). This was probably attributed at least, in part, to the choice of shallow, murky dive sites. The most numerous fishes counted in SPCs were *Naso unicornis* (39), *Chlorurus perspicillatus* (31), *Kyphosus spp.* (18), and *Thalassoma ballieui* (18).

BLT data

A total of 4031 fish of 80 species were counted at the 9 sites on BLT transects. This reflects a fish density of 0.75 fishes/m^2. By far, the most numerically abundant species were *Thalassoma duperrey* (977 individuals counted) and *Stegastes fasciolatus* (568). Also numerous were *Mulloidichthys flavolineatus* (289 individuals counted), *Acanthurus triostegus* (153), *Mulloidichthys flavolineatus* (117), *Plectroglyphidodon johnstonianus* (112), *Chromis ovalis* (110), and unidentified juvenile *Scarus spp.* (106). The size frequencies of all fishes counted are presented in Figure H.4.1.1.

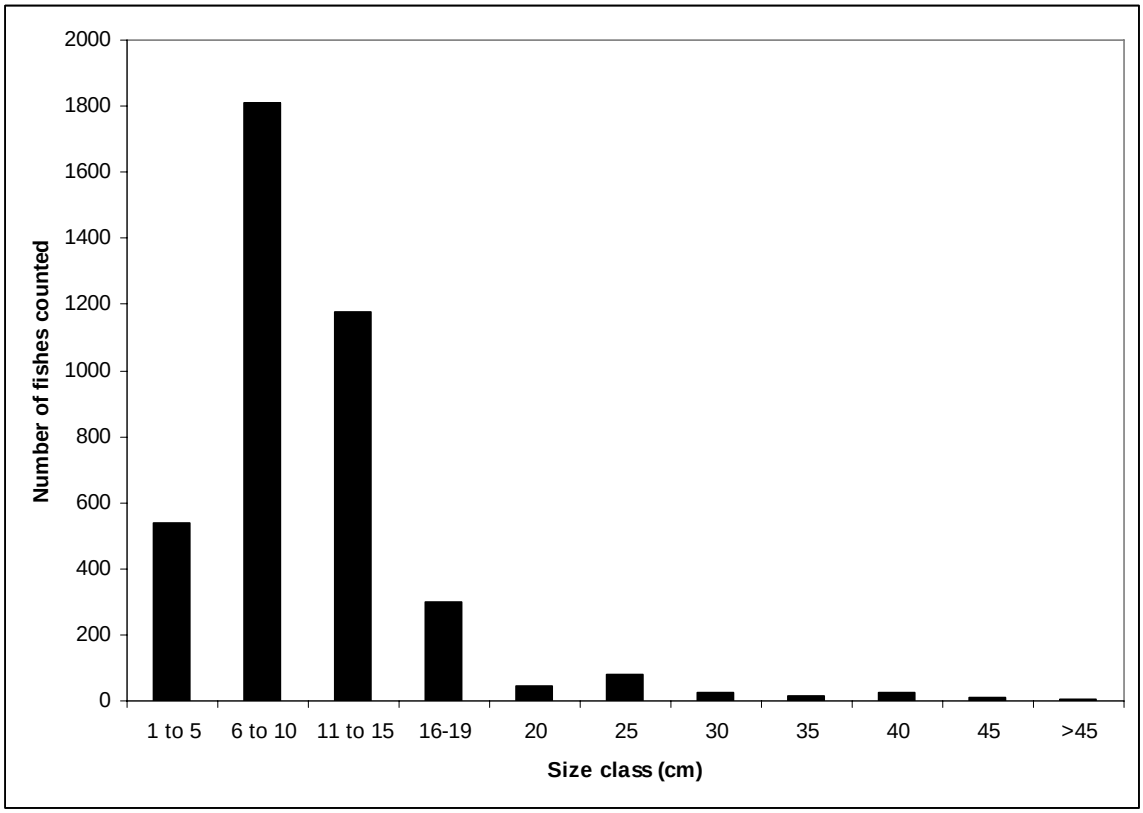

Figure H.4.1.1. Size frequencies of fish at Kure Atoll.

Only five fishes larger than 45 cm were seen on BLT transects.

Overall observations:

One hundred twenty-eight species of fishes were recorded at Kure Atoll. Although we did not count them on transects, we did see quite a few *Carcharhinus galapagensis* over the course of our Kure dives, perhaps the most of any of the atolls visited. They would generally turn up after we were around and making noise pounding pins for a while, but these fishes lurked in the distance.

H.4.2 Towed-diver Fish Surveys

Table H.4.2.1. HI06_11 Towed-Diver Survey Report for Kure Atoll.

			Survey Length				Mean Depth
		N	**Min**	**Max**	**Median**	**Sum**	**Median**
Kure Atoll	**09/17/2006**	6	1.85	2.81	2.17	13.71	-9.27
	09/18/2006	6	2.08	2.40	2.33	13.70	-10.10
	09/19/2006	1	1.85	1.85	1.85	1.85	-0.67
	All	13	1.85	2.81	2.28	29.27	-9.89

N = number of surveys conducted.

Survey Length is given in kilometers.

Depth readings are taken at 5 sec intervals during each 50 min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of 13 species of large fishes (>50 cm TL) representing 11 families were observed at Kure Atoll during the survey period (09/17/06–09/19/06). The mean number of fishes (all species pooled) observed by divers was 0.096 ha^{-1} and the ten mostly commonly recorded species are shown in Figure H.4.2.1. The spectacled parrotfish (*Chlorurus perspicillatus*) was the most abundant species observed during the quantitative surveys with a mean number of 1.92 fishes observed per hectare. The green jobfish (*Aprion virescens*) was the second most abundant fish species with a mean numeric density of 0.523 ha^{-1}.

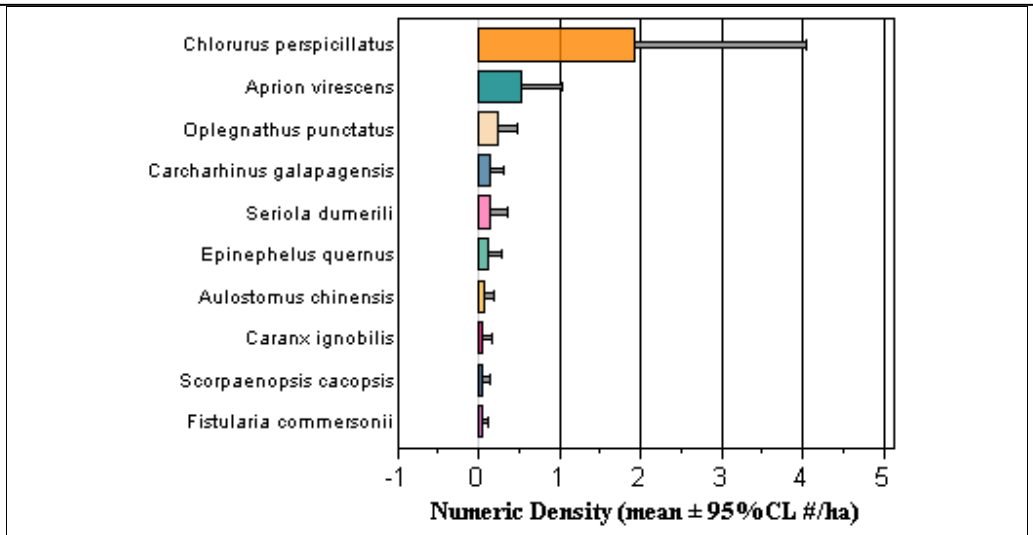

Figure H.4.2.1. The mean numeric density (number of fishes ha^{-1}) of the ten most commonly observed fishes at Kure Atoll during the survey period.

The grand mean biomass density of fishes observed on the shallow-reefs (<30 m) at Kure Atoll during the survey period was 7.70 x 10-4 t ha-1. The spectacled parrotfish (*Chlorurus perspicillatus*) and the Galapagos shark (*Carcharhinus galapagensis*) accounted for more than 65% of the total recorded fish biomass (Fig. H.4.2.2). The mean biomass density of spectacled parrotfishes was 9.60 x 10-3 t ha-1, and the mean biomass density of Galapagos sharks was 6.40 x 10-3 t ha-1.

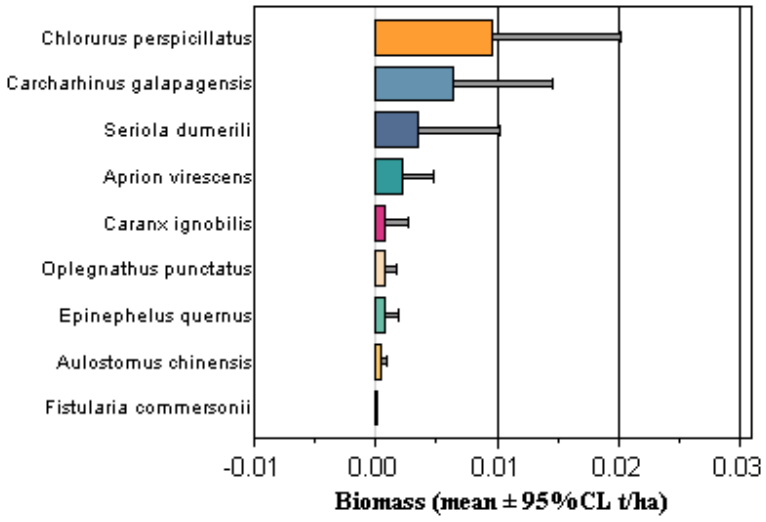

Figure H.4.2.2. The mean biomass (t ha^{-1}) of the nine most commonly observed fishes larger than 50 cm (TL) at Kure Atoll during the survey period.

H.4.3 Shark Receivers

We recovered, downloaded, and redeployed three receivers (Table 1), and refurbished the ground tackle for two of these units (West Channel, Southeast Channel). The old ground tackle was removed from the reef at these locations.

H.5. Maps

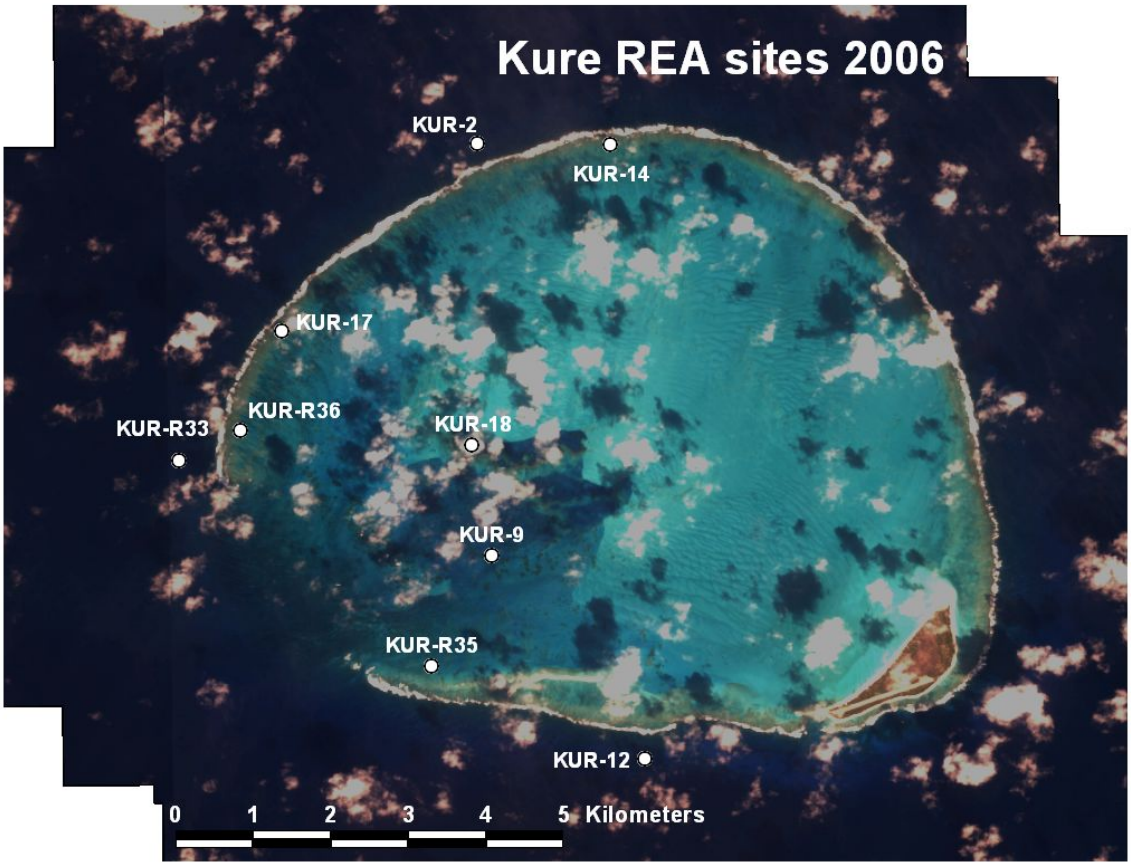

Figure H.5.1. Map showing location of 2006 Rapid Ecological Monitoring (REA) sites at Kure Atoll.

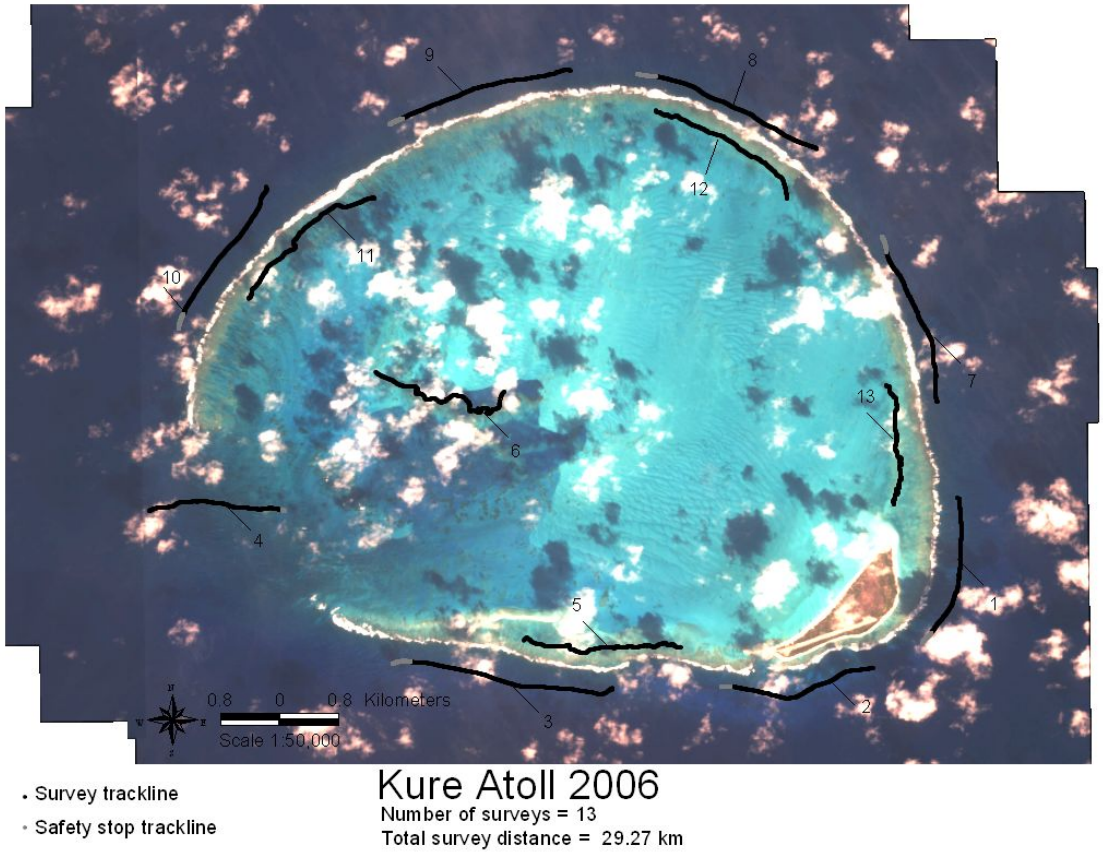

Figure H.5.2. Map showing location of towboard tracks at Kure Atoll.

Appendix I: Midway Atoll

I.1. Oceanography and Water Quality

In total, eight instruments were deployed and seven instruments were recovered at Midway Atoll. One ocean data platform (ODP) plate located on the west side of Midway was removed and replaced with a new instrument plate reusing existing anchor (Fig. I.1.1). One sea surface temperature (SST) buoy and anchor was deployed in the interior of the lagoon. The previously deployed SST was recovered during a marine debris cruise in 2005. Five subsurface temperature recorders (STR) were recovered and replaced; four located in shallow backreef habitat and one attached to the SST anchor in the lagoon. Deployed STRs were set to record data for an additional 2 years. A new STR deployment site, colocated with REA site R7 was established on the southern forereef in 14 m of water.

Thirteen shallow-water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Midway Atoll following the 30-m contour. At 4 of these locations, one on each side of the island, water sample profiles were performed for a total of 18 water samples measuring chlorophyll and nutrient levels. All water sample profiles were conducted concurrently with CTD casts.

The ODP located in the west channel returned a timeseries of temperature and salinity at 30 m depth (Fig. I.1.2). Temperature varies seasonally with the warmest temperatures (25–27 °C) observed during August and September and the coolest temperatures (18–19 °C) during February and March (Fig. I.1.2, top panel). Superposed with seasonal variance are high frequency temperature fluctuations. A 2-week expansion shows that changes of 2–6 °C occurred one to two times daily (Fig. I.1.2, bottom panel). Although these fluctuations are observed periodically throughout the 2-year data set, they are most prevalent from May to November 2005. Salinity data shows less seasonal dependence than temperature, as sporadic changes in salinity are observed on intraseasonal timescales (Fig. I.1.2, top panel). However, as seen in the temperature record, high frequency fluctuations are observed in salinity values, particularly during the period of May to November 2005. A 2-week expansion shows salinity was tightly correlated with temperature, as sharp drops in salinity occur with sharp drops in temperature Spectral analysis of the temperature and salinity record shows the dominant frequency peaking at the semidiurnal (~12 hours) and diurnal (~24 hours) periods.

Given the correlation between the temperature and salinity data sets and the similarity in the forcing frequency, it is likely that either barotropic or baroclinic tidal fluctuations are driving the variability. One theory is that barotropic tides result in the horizontal advection of water masses, causing the 30-m deep sensor to be in warm, more saline, lagoonal-derived waters during the outgoing phase (low tide) of the tidal cycle, and in cooler, less saline, oceanic waters during the incoming phase (high tide). A second theory is that internal tides, either remotely or locally generated, are causing vertical advection of the background stratification, resulting in warm spikes during certain phases of the tidal cycle and in stratified, colder waters during the remaining cycle. The exact source of the observed temperature and salinity fluctuations is unknown without additional data.

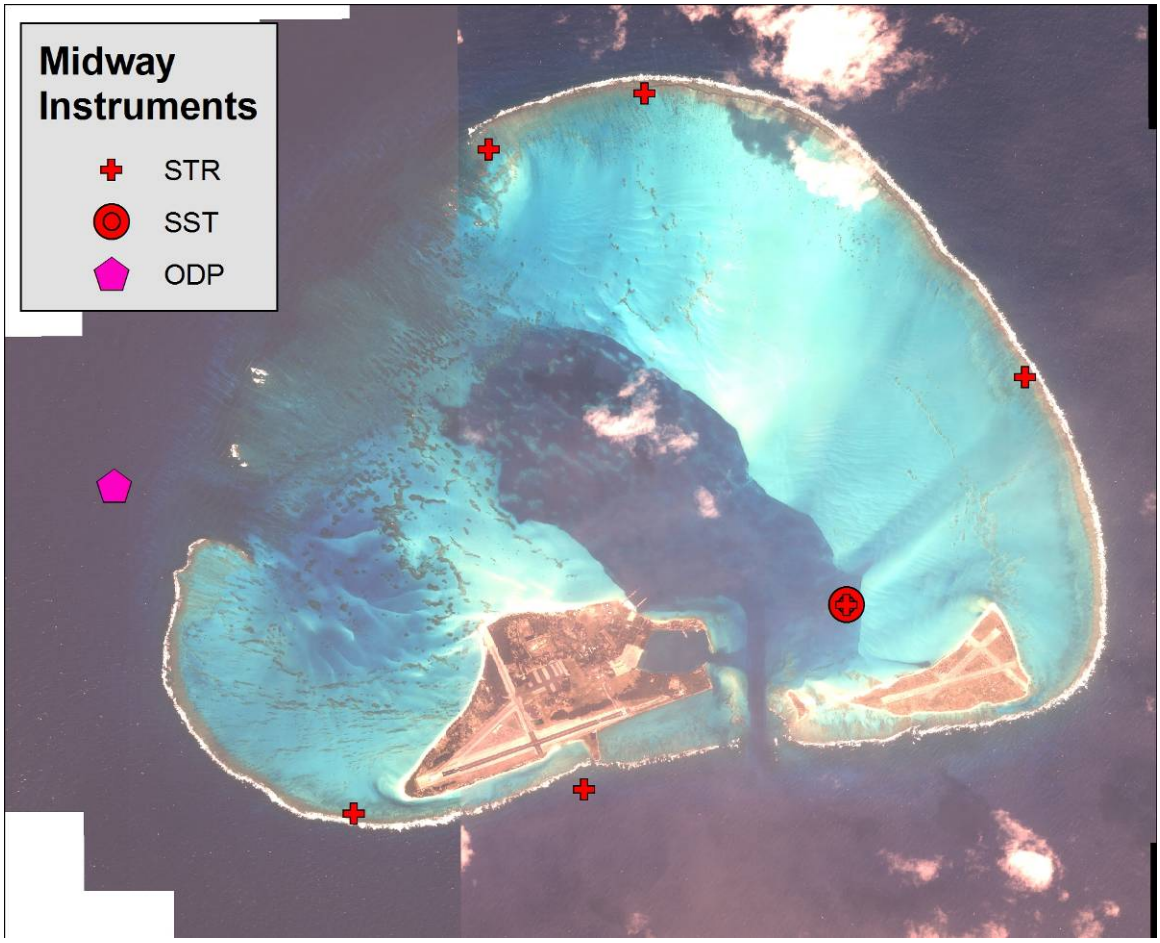

Figure I.1.1: IKONOS satellite image showing Coral Reef Ecosystem Division (CRED) oceanographic instrumentation deployed during HI0611.

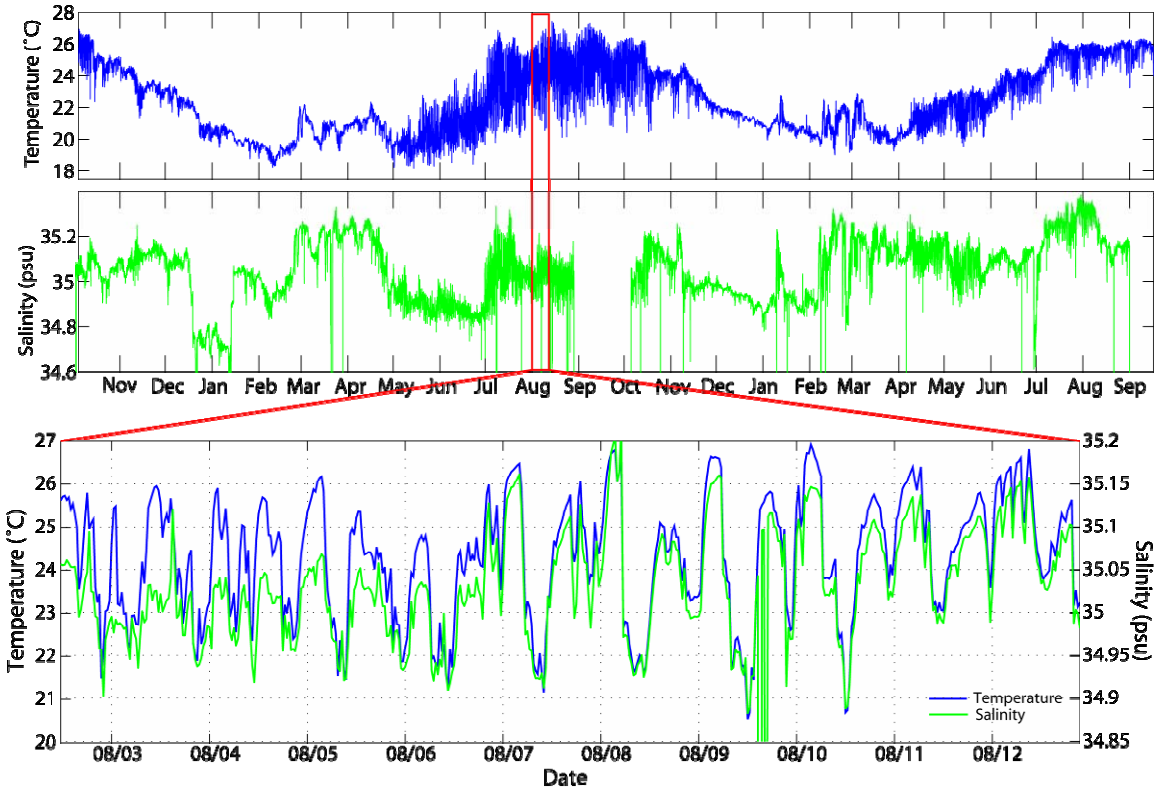

Figure I.1.2: Two-year timeseries of temperature (°C) and salinity (psu) obtained from the ODP located on the western side of Midway Atoll at 30 m depth (top panel). Bottom panel depicts a 2-week expansion of the temperature and salinity. In each plot, temperature (left vertical axis) is plotted in blue and salinity (right vertical axis) plotted in green.

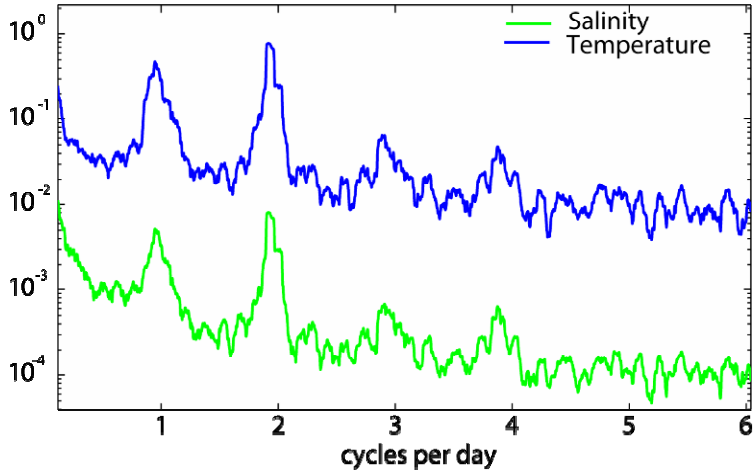

Figure I.1.3: Power spectra for temperature (blue) and salinity (green) showing peaks at the semidiurnal and diurnal tidal periods. The horizontal axis is in cycles per day and the vertical axis is logarithmic and in $°C^2$/cycles per day for temperature and psu^2/cycles per day for salinity.

I.2. Rapid Ecological Assessment (REA) Site Descriptions

MID-2
September 15, 2006

South, fringing forereef; depth range: 12–13.5 m, visibility ~20 m; temperature: 25 °C, which is 2 °C cooler in 2006 than same time of year in 2004. New permanent transects installed. Moderate topographic complexity, composed of carbonate promontories interspersed by sand pockets. Carbonate substrate bioeroded and epiphytized by macroalgae and turf algae; abundant *Echinostrephus* on the carbonate terrain, sheltered in bore-holes. This forereef site was located east of the main channel into Midway lagoon. The area was characterized by extensive sand patches with small patch reefs. A species of *Dictyota* was extremely abundant, and large "tumbleweeds" filled the water column. Algal diversity was surprisingly high. Within photoquadrats, we recorded turf algae, very short patches of *Microdictyon setchellianum* (probably cropped down because of grazing pressures), *Trichogloea requienii*, *Laurencia galtsoffii*, *Padina* spp., *Halimeda velasquezii*, *H. discoidea*, crustose coralline red algae, and *Dasya kristeniae*. *Dictyosphaeria cavernosa*, *Liagora pinnata*, and *Dasya iridescens* were found during the random swim. Low coral cover (1.9%); two coral species on point-count transect: *Pocillopora meandrina* and *Psammocora stellata*; small colony size. Turf algae accounted for >50% of the benthic cover. Numerous were *Pocillopora meandrina* with their tips bitten off by fish. Four scleractinian species enumerated within 50 m^2 belt transects. No additional scleractinian species observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (300 m^2), no other afflictions to corals were observed within the survey area. This site did not have a lot of shelter for fishes, and was rather depauperate in terms of abundance and diversity. It was dominated by wrasses, such as *Thalassoma duperrey* and *Coris venusta*, and damselfishes. The SPC diver saw *Naso unicornis*. Off of the transects on our REAs, we saw morwongs, a huge *Parupeneus cyclostomus*, some *Myripristis berndti*, and some tiny surgeonfish recruits (*Zebrasoma flavescens* and *Acanthurus olivaceous*). A small Galapagos shark cruised by once or twice.

MID-R7
September 15, 2006

South, fringing forereef; depth range: 13–14.8 m, visibility ~25 m; water temperature: 25 °C, which is 2 °C cooler in 2006 than same time of year in 2004. Permanent transects where also installed. Elaborate and uneven carbonate terrain with moderate topographic complexity. This barren forereef site was located west of the main channel into Midway lagoon. The substrate was covered with turf algae sparsely intermingled with minute individuals of crustose coralline red algae, *Dictyota* spp., *Lobophora variegata*, non-geniculate calcified branched red algae, species of *Padina*, and cyanophytes. No additional algal material was found during the random swim.

Live coral cover amounted to 7.8%; *Porites lobata* was the only scleractinian enumerated along the point-count transect. Other corals present in the area included *Leptastrea purpurea, Psammocora stellata,* and *Pocillopora* cf. *meandrina*. Highly fissioned *Porites lobata* most common coral. Four scleractinian species enumerated within 50 m^2 belt transects. No additional scleractinian species observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (150 m^2), no coral diseases were noted. However, several cases of compromised health state were observed, including one case of pigmentation response and three cases of discoloration, all on *Porites lobata*. This site had good fish abundances. We saw lots of damselfishes, particularly *Chromis ovalis,* and lots of kyphosids. The SPC diver saw primarily triggerfishes and one *Seriola dumerlii*. The parrotfish here were exceptionally large, and there were lots of cleanerfishes. We noted *Lutjanus kasmira,* both species of *Oplegnathus,* some gigantic *Parupeneus porphyreus, Cheilodactylus vittatus,* and a few Galapagos sharks.

MID-R3
September 15, 2006

South, fringing forereef; depth range: 14–17.6 m, visibility ~30 m; water temperature: 24.5 °C, water temperature: 25 °C, which is 2 °C cooler in 2006 than same time of year in 2004. New permanent transects installed. Elaborate and uneven carbonate terrain with moderately high topographic complexity. Rutted, bioeroded carbonate surface epiphytized by turf-algae; significant boring activity by echinoid grazers (*Enchinometra* and *Echinostrephus*). This barren forereef site was located at the southwest corner of the atoll. Turf algae covered the substrate. All macroalgal species encountered were so small that they could have almost been considered part of the turf algal community. These included species of *Dictyota, Halimeda velasquezii, Lobophora variegata* (both blade-like and encrusting forms), *Neomeris* sp., *Stypopodium flabelliformae, Padina* spp., and cyanophytes. Small individuals of crustose coralline red algae and non-geniculate calcified branched red algae were also observed. Live coral cover amounted to 7.8%; *Porites lobata* was the only scleractinian enumerated along the point-count transect. However, other corals present in the general area included: *Leptastrea purpurea, Psammocora stellata, Pocillopora* cf. *meandrina, Letposeris incrustans, Montipora capitata,* and *Montipora turgescens*. Highly fissioned *Porites lobata* most common coral. Six anthozoan species enumerated within 50 m^2 belt transects. Three additional scleractinian species (*Montipora capitata, M. turgescens, Pavona varians*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (225 m^2; assessment on first transect limited to half tape because of limited bottom time), one case of tissue loss was noted on *Porites lobata*. Additionally, several cases of compromised health states were observed, including five cases of pigmentation response and one case of discoloration, all on *Porites lobata*. This site was great! A large school of *Caranx ignobilis* (~40 fish) greeted us when we jumped in. There were schools of everything —kyphosids, including three golden individuals, *Chromis ovalis, Naso hexacanthus, Naso brevirostris, Naso unicornis, Naso maculatus,*and *Naso caesius.* There were lots of large terminal wrasse around, such as *Coris flavovittata* and *Bodianus bilunulatus.* We also saw ta'ape here and lots of *Labroides*

phthirophagous. Rare species included *Apolemi arcuatus*, *Genicanthus personatus*, *Oplegnathus punctatus*, *Myripristis chryseres, Cheilodactylus vittatus* and *Aetobatis narinara.* To top it off, we saw lots of *Aprion virescens, Caranx melampygus,* and *Carcharhinus galapagensis* (eight were circling on our safety stop). What a great dive!

MID-3
September 16, 2006

Internal lagoon patch reef; depth range 4.6–9.1 m; visibility: 20 m; temperature: 24.5 °C. This site was composed of two coral bommies or twin *Porites compressa*-built, patch reef pinnacles surrounded by carbonate sand/silt plain. Heavily bioeroded framework with a numerous amount of holothurians. Used permanent transects (2, 25 m) installed by Jim Maragos (Rrm7), each of which went from base to top to base of an individual pinnacle. Most corals were dead, and the bommies were heavily colonized by turf algae, encrusting *Lobophora variegata*, and crustose coralline red algae. Macroalgae recorded included: *Dictyosphaeria cavernosa*, *D. versluysii*, *Caulerpa serrulata*, *Galaxaura* sp., *Halimeda velasquezii*, *Microdictyon setchellianum*, possibly *Phyllodictyon anastomosans*, a species of *Sargassum*, and *Asparagopsis taxiformis*. Live coral cover was 3%. Point count transect 1 and 2 measured 16 and 13 m, respectively. Only *Porites compressa* enumerated along the point-count transects; however, other scleractinians present at the site included *Pocillopora damicornis*, *Pavona varians*, *Porites lobata*, and *Cyphastrea ocellina*. This site was not surveyed in 2004 because of time constraints. Five scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Psammocora stellata*) observed in larger area outside belt transects.

Coral disease and health assessment: Within the survey plot (175 m^2) no diseased corals were observed. This set of micro patch-reefs was dominated by kyphosids and goatfish. There was very little fish habitat, and there were small wrasses and parrotfish associated with the coral. Interesting sightings included *Pseudocaranx dentex* and *Pterois sphex*. A large kahala also came through at one point.

MID-R20
September 16, 2006

East, shallow backreef; depth range: 0.9–2m, visibility ~20 m; temperature: 24.5 °C. Used permanent transects (2, 25 m) installed by Jim Maragos (17P) which run from lagoon towards the reef crest. This site was too shallow to dive; surveyed by all teams via snorkel. Very strong surge; could only videotape and survey one transect line for corals. Highly eroded carbonate alternating with areas of rubble with numerous *Heterocentrotus mammilatus.* Uneven carbonate terrain with moderately topographic complexity. Rutted and bioeroded carbonate masses, interspersed with pavement, rubble, and sand pockets. Carbonate surfaces epiphytized with turf-algae. Extremely high current washing over the reef crest from a large northeast swell made this backreef site very difficult to work. Only a qualitative algal survey was conducted. Species or functional groups encountered included *Laurencia galtsoffii*, *Turbinaria ornata*, *Stypopodium flabelliformae*, *Microdictyon setchellianum*, turf algae, crustose coralline red algae, *Halimeda velasquezii*, and

Chondrophycus parvipallatus. Low live coral cover amounted to 7.8%; *Porites lobata* and *Pocillopora cf. meandrina* were the only scleractinians enumerated along the point-count transects. However, other corals present in the general area included *Leptastrea purpurea*, *Cyphastrea ocellina*, *Pocillopora* cf. *damicornis*, *Leptastrea purpurea*, and *Porites* cf. *evermani*/*lutea*. Overall, *Porites lobata* seemed to be the most common coral, forming structures similar to microatolls. Three scleractinian species enumerated within 25 m^2 belt transect. Two additional scleractinian species (*Cyphastrea ocellina, Leptastrea purpurea*) observed in larger area outside belt transect.

Coral disease and health assessment: Within the survey plot (75 m^2; assessment on half of second transect only as a result of difficult diving conditions), one case of tissue loss was noted on *Porites lobata*. This site was dominated by wrasses and a HUUUUUGE school of *Acanthurus triostegus.* One diver saw small schools of *Caranx ferdau* and *Caranx orthogrammus.* There were some *Hyporhamphus aculeatus* around the surface as well.

MID-R25
September 16, 2006

South-southwest, shallow backreef; depth range: 0.9–2.1 m; visibility ~20 m; temperature: 25.5 °C, which is 2 °C cooler in 2006 than same time of year in 2004. Uneven carbonate terrain with moderately topographic complexity; comparable to site MID-R20. Used permanent transects (2, 25 m) installed by Jim Maragos (19P) which run from lagoon towards the reef crest. Very strong surge, difficult to survey. The site was composed of highly eroded carbonate alternating with areas of pavement, rubble, sand pockets, and numerous *Heterocentrotus mammilatus*. Most carbonate surfaces were epiphytized with turf-algae. This southern backreef site also had extremely high current. We had to crawl along the bottom to reach our survey points, but miraculously managed to sample all photoquadrats. The benthos was dominated by turf algae and encrusting *Lobophora variegata*. We also found species of *Padina*, crustose coralline red algae, *Microdictyon setchellianum*, *Dictyota* spp., *Laurencia galtsoffii*, and *Turbinaria ornata* inside the photoquadrats. A species of *Neomeris* was found during the random swim. Five scleractinian species enumerated within 25 m^2 belt transect. No additional scleractinian species observed in larger area outside belt transect. Live coral cover amounted to <1%; *Pocillopora* cf. *meandrina* was the only scleractinian enumerated along the point-count transect. However, a few large colonies of *Porites lobata*, substantially bioeroded by *Heterocentrotus mamillatus* and *Enhinometra mathaei* were present at the beginning of transects 1 and 2. Other corals present in the general area included *Leptastrea purpurea*, *Psammocora stellata*, *Pocillopora* cf. *damicornis*, and *Letposeris incrustans*.

Coral disease and health assessment: Within the survey plot (300 m^2), one case of multifocal tissue loss was noted on *Porites lobata*. Additionally, one case of compromised health state was observed, involving pigmentation response on *Porites lobata*. No additional afflictions to corals were observed within the survey area. This very shallow site was characterized by a lot of damselfishes (*Dascyllus albisella* and *Stegastes fasciolatus*), a fair number of *Coris flavovittata*, and *Calotomus zonarchus* were also present. SPC diver saw a

lot of *Mulloidichthys flavolineatus* and *Chlorurus perspicillatus* and *Naso unicornis.* Unusual sightings included *Cymolutes lecluse* and about fifty nehu, *Encrasicholina purpurea.*

MID-1
September 21, 2006

North, shallow backreef; depth range: 0.2–1.2 m; visibility ~15 m; temperature: 26.1 °C. survey; used permanent transects installed by Greta Aeby in 2005. Transect oriented somewhat perpendicular to reef crest. Uneven carbonate terrain with moderately topographic complexity; bioeroded carbonate surfaces interspersed with pavement, rubble, and sand pockets. Carbonate surfaces epiphytized with turf-algae. This backreef site was dominated by Montiporid corals. In many quadrats, algae occupied <5% of the space. The algal community consisted of turf algae, *Laurencia galtsoffii*, *Lobophora variegata*, cyanophytes, *Halimeda velasquezii*, *H. opuntia*, *Boodlea composita*, *Neomeris* sp., crustose coralline red algae, and a species of *Galaxaura*. Live coral cover was close to 54%; overwhelmingly dominated by *Montipora flabellata*, all well pigmented. Note: Because of surge, *M. turgescens*, if present, was not distinguished from *M. flabellata*. In deeper water, *M. capitata* mounds that heavily bleached in 2002 are largely dead (carbonate) overgrown with turf algae. Remaining live *M. capitata* is well pigmented. Four scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Leptastrea purpurea*) observed in larger area outside belt transects. *Montipora flabellata* was the only scleractinian enumerated along the point-count transect, forming extensive and monotypic carpets.

Coral disease and health assessment: Within the survey plot (300m^2), no afflictions to corals were observed. However, outside the survey area, three cases of tissue loss were detected on *Montipora flabellata*. It is possible that these lesions are caused by predators; nonetheless, small tissue samples were procured for histological analyses. This dreadfully shallow site was characterized by an abundance of wrasses, particularly *Thalassoma duperrey*, *Stethojulis balteata*, and *Thalassoma duperrey*. There were also a large number of the ubiquitous *Stegastes fasciolatus.* The SPC diver saw a total of three *Chlorurus perspicillatus* on his four replicates.

MID-H21
September 12, 2006

North, shallow backreef; depth range: 0.9–1.2 m; visibility ~15 m; temperature: 26.1 °C. Snorkel survey. Looked for permanent transect markers installed by Maragos in 2002 (Rrm3); not finding them, we were than informed by Maragos that he had probably written the coordinates incorrectly, i.e., no such markers at this location. Installed new permanent transects (2, 25 m). Current strengthened during marker installation and benthic survey. Comparable topography and composition to prior site; transect was oriented parallel to the reef crest. Bioeroded carbonate surfaces interspersed with pavement, rubble, and sand pockets. This shallow backreef site was located on the northern side of the atoll close to the "Reef Hotel." The algal community contained turf algae, *Microdictyon setchellianum*, *Lobophora variegata*, crustose coralline red algae, *Halimeda velasquezii*, *H. discoidea*, *Dictyosphaeria versluysii*, a short wiry species of *Sargassum*, *Neomeris* sp., *Galaxaura* sp.,

and *Laurencia galtsoffii*. Live coral cover was lower than site MID-H21; 29%; dominated by *Montipora flabellata*, although colonies not as large or contiguous as at MID-1; instead, colonies are separated by areas of carbonate and rubble. Note: because of strong current, *M. turgescens*, if present, was not distinguished from *M. flabellata*. *Montipora capitata* mounds in deeper water (8 to 10 feet) that bleached heavily in 2002 had variable appearance: some have considerable live *M. capitata* cover; others are dead/covered with turf algae. Five scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Porites evermanni*) observed in larger area outside belt transects. *Montipora flabellata* and *Cyphastrea ocellina* were the only two corals enumerated along the point-count transects.

Coral disease and health assessment: Within the survey plot (300 m^2), three cases of tissue loss were detected on *Montipora flabellata*. Aside from these, no other afflictions to corals were observed within the survey area. Additionally one case of advanced discoloration was detected on *Montipora* cf. *capitata*; this case was observed outside the survey area. A small tissue sample was procured for histological analyses. No photographs were taken of the sample specimen because of rough sea conditions. This site had a lot of *Thalassoma duperrey* and *Stegastes fasciolatus*, and as a bonus there were a large number of butterflyfishes, particularly *Chaetodon lunulatus* and *Chaetodon auriga*. There were a large number of *Acanthurus triostegus* as well. The SPC diver saw hardly any large fish near the transect, and had three replicates with no fishes counted at all. Away from the transect, however, there were a large number of large fishes including a school of large initial phase *Chlorurus perspicillatus* and a couple of very large *Oplegnathus punctatus*. This discrepancy may be because the transect was so darn shallow that there was not enough water for the fish to swim in.

MID-H11
September 21, 2006

Central lagoon; shallow patch reef; depth range: 3.0–5.5 m; visibility ~10 m; temperature: 26.1 °C. New permanent transects (2, 25 m) installed. Dome-shaped patch reef, with moderately low topographic relief. Carbonate surfaces heavily bioeroded, mainly by echinoid grazers (numerous *Echinometra* and *Heterocentrotus*). This lagoonal patch reef was extremely diverse in terms of algae; unfortunately the swell conditions made collecting very difficult. Within photoquadrats we recorded turf algae, *Microdictyon setchellianum*, *Lobophora variegata*, crustose coralline red algae, *Turbinaria ornata*, *Boodlea composita*, species of *Padina*, *Halimeda velasquezii*, *Stypopodium flabelliformae*, *Dictyosphaeria cavernosa*, species of *Dictyota*, and a species of *Liagora*. *Dasya iridescens*, *Asparagopsis taxiformis*, and a species of *Galaxaura* were found during the random swim. Low live coral cover was 6.9%; *Pocillopora damicornis* and *P. meandrina* most common corals. Two scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Porites lobata*) observed in larger area outside belt transects. *Pocillopora cf. meandrina* was the only scleractinian enumerated along the point-count transects. Macroalgae and turf-algae colonized carbonate surfaces comprised over 73% of the benthic cover.

Coral disease and health assessment: Within the survey plot (300 m^2), no coral diseases were observed. However, three cases of compromised health conditions on *Pocillopora* were detected. These involved focal to diffuse pallor, as well as partial mortality and fleshy and coralline algal overgrowth. This site, which we affectionately call "surge-o-rama central," had an astonishing number of *Stegastes fasciolatus*. The sheer number of them was remarkable—it was as if the reef were moving. *Thalassoma duperrey* also was present in incredibly high abundance. There were a lot of *Coris flavovittata* around as well as a very large school of *Mulloidichthys flavolineatus*. SPC diver saw predominantly *Coris flavovittata, Naso unicornis,* and *Kyphosus spp.* One Galapagos shark was seen on this dive.

I.3. Benthic Environment

I.3.1. Algae

Quantitative algal surveys were conducted at nine sites on the south, west, and east sides of the fringing reef at Midway Atoll (MID-2, MID-R-7, MID-R-3, MID-R-20, MID-R-25, MID-3, MID-1, MID-H21, MID-H11). The sites located on the fringing forereef were characterized by moderate topographic complexity, composed of carbonate promontories interspersed by sand pockets. The rutted and bioeroded carbonate surface covered by turf-algae is thought to be a result from the significant boring activity by echinoid grazers (*Enchinometra, Echinostrephus,* and *Heterocentrotus mamillatus*). The rest of the sites were composed of lagoonal patch reef and shallow backreefs. Prominent algal species found at most sites include *Halimeda velasquezii, Neomeris* spp., *Microdictyon setchellianum, Laurencia gattsoffii, Galaxaura* spp., *Dictyota* spp, *Padina* spp., and *Lobophora variegata.* Overall, 10 species of green algae, 11 species of red algae, and 6 species of brown algae were collected. In addition microscopic examination of epiphytes will increase the number of species collected substantially, especially among the red algae.

Table I.3.1.1: Algal genera or functional groups recorded in photoquadrats at Midway Atoll. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	MID-2	MID-R-7	MID-R-3	MID-R-20	MID-R-25	MID-3
GREEN ALGAE						
Caulerpa	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**
Dictyosphaeria	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**3.3**
Halimeda	*41.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	3.8	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Microdictyon	*33.3*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*
	1.8	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**
RED ALGAE						
Non-geniculate calcified branched red algae	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**

	MID-2	MID-R-7	MID-R-3	MID-R-20	MID-R-25	MID-3
crustose coralline algae	*8.3*	*50.0*	*0.0*	*0.0*	*0.0*	*0.0*
	3.0	**2.8**	**0.0**	**0.0**	**0.0**	**0.0**
Dasya kristeniae	*16.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	3.5	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Laurencia	*8.3*	*0.0*	*0.0*	*0.0*	*33.3*	*0.0*
	2.0	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**
BROWN ALGAE						
Dictyota	*41.7*	*91.7*	*0.0*	*0.0*	*8.3*	*0.0*
	2.8	**2.4**	**0.0**	**0.0**	**4.0**	**0.0**
Lobophora	*0.0*	*58.3*	*0.0*	*0.0*	*58.3*	*41.7*
	0.0	**3.4**	**0.0**	**0.0**	**2.3**	**2.0**
Padina	*50.0*	*16.7*	*0.0*	*0.0*	*8.3*	*0.0*
	3.2	**3.5**	**0.0**	**0.0**	**3.0**	**0.0**
Turbinaria	**0.0**	**0.0**	**0.0**	*0.0*	*8.3*	*0.0*
	0.0	*0.0*	*0.0*	**0.0**	**6.0**	**0.0**
FUNCTIONAL GROUPS						
turf algae	*66.7*	*91.66*	*0*	*0.0*	*100*	*0*
	1.0	**1.0**	**0.0**	**0.0**	**1.0**	**0.0**
cyanophytes	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*8.3*
	0.0	**3.0**	**0.0**	**0.0**	**0.0**	**1.0**

Table I.3.1.2: Putative algal species found at Midway Atoll. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis

List of putative macroalgal species collected
(one sample per site)

	MID-2	MID-R-7	MID-R-3	MID-R-20	MID-R-25	MID-3	MID-1	MID-H21	MID-H11
GREEN ALGAE									
Boodlea composita							X		X
Caulerpa serrulata						X			
Dictyosphaeria versluysii						X		X	
Dictyosphaeria cavernosa	X					X			X
Halimeda discoidea	X							X	
Halimeda opuntia							X		
Halimeda velasquezii	X		X	X		X	X	X	X
Microdictyon setchellianum	X			X	X	X		X	X
Neomeris sp.			X		X		X	X	
Phyllodiction anastomosans						X			
RED ALGAE									
Asparagopsis taxiformis						X			X
Non-geniculate calcified branched red algae		X	X						
Chondrophycus parvipapillatus				X					
Daya kristeniae	X								
Dasya iridescens	X								X
Galaxaura spp						X	X	X	X

Laurencia gattsoffii	X			X	X		X	X	
Liagora spp									X
Liagora pinnata	X								
Tricleocarpa	X								
Trichlogoea	X								
BROWN ALGAE									
Dictyota spp.	X	X	X		X				X
Lobophora variegata		X	X		X	X	X	X	X
Padina spp.	X	X	X		X				X
Sargassum spp.						X		X	
Stypododium flabelliformae			X	X					X
Turbinaria ornata				X	X				X

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I.3.2. Corals

Coral REA surveys were conducted at 9 of the 11 sites that were selected by CRED and partners in 2003 for long-term monitoring. The 2003 site selection regime was based on the assumption that 4 days of field surveys would be allocated at Midway Atoll. However, in 2006 as well as in 2004, when the most recent CRED surveys were conducted at Midway, only 3 days were allocated for field surveys. Of the nine sites surveyed in 2006, two (MID-3 and MID-H11) had been most recently surveyed by CRED in 2003. Two of the sites selected for long-term monitoring in 2003 were not surveyed in 2006 (MID-H10 and MID-R15) because of time constraints and adverse sea conditions. Both of the latter sites were surveyed by the NWHI Coral Reef Ecosystem Reserve in September 2005, as were four other long-term monitoring sites (MID-1, MID-H1, MID-R7, and MID-2).

At four of the sites surveyed in 2006, permanent transect markers had been installed by Dr. James Maragos in 2001 or 2002 (MID-R20, MID-R25, and MID-3) or by Dr. Greta Aeby in 2005 (MID-1). These markers were used by the REA survey team this year to guide deployment of transect lines (2, 25 m per site). Permanent transect markers were installed at the remaining five sites this year along the first two transects by members of the REA fish team with the intention of reducing error attributed to spatial imprecision on future surveys. GPS site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded in order to facilitate relocating the markers on future surveys.

I.3.2.1 Coral populations

A total of 1158 colonies belonging to 15 anthozoan taxa was enumerated within belt transects enclosing 425 m^2 benthic substrate (Table I.3.2.1). The most frequently occurring taxa were *Porites lobata*, *Montipora flabellata*, and *Pocillopora meadrina*. One additional scleractinian species not seen within belt transects was observed within the larger survey area surrounding the transect belts (*Montipora turgescens*).

Table I.3.2.1. Number of anthozoans enumerated within belt transects at Midway Atoll during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Taxon	# of colonies	Percent of total
Acropora cytherea	0	0.0
Acropora valida	0	0.0
Acropora humilis	0	0.0
Montipora capitata	13	1.1
Montipora patula	1	0.1
Montipora verilli	0	0.0
Montipora flabellata	158	**13.6**
Montipora turgescens	0	0.0
Montipora incrassata	0	0.0
Pavona duerdeni	0	0.0
Pavona varians	5	0.4
Cyphastrea ocellina	11	0.9
Leptastrea purpurea	13	1.1
Fungia scutaria	0	0.0
Leptoseris incrustans	1	0.1
Pocillopora damicornis	99	8.5
Pocillopora eydouxi	0	0.0
Pocillopora ligulata	2	0.2
Pocillopora meandrina	131	**11.3**
Porites brighami	0	0.0
Porites compressa	73	6.3
Porites evermanni	1	0.1
Porites lobata	647	**55.9**
Psammocora stellata	2	0.2
Palythoa sp.	1	0.1
Zoanthus pacifica	0	0.0
Total # colonies	1158	100.0
Area surveyed, m^2	425	

A size class distribution of all corals enumerated within belt transects is shown in Figure I.3.2.1. Of the 1158 colonies whose maximum diameter was visually estimated, 67.4% had a maximum diameter <10 cm, and 5.0% had a maximum diameter >40 cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003–2004 surveys.

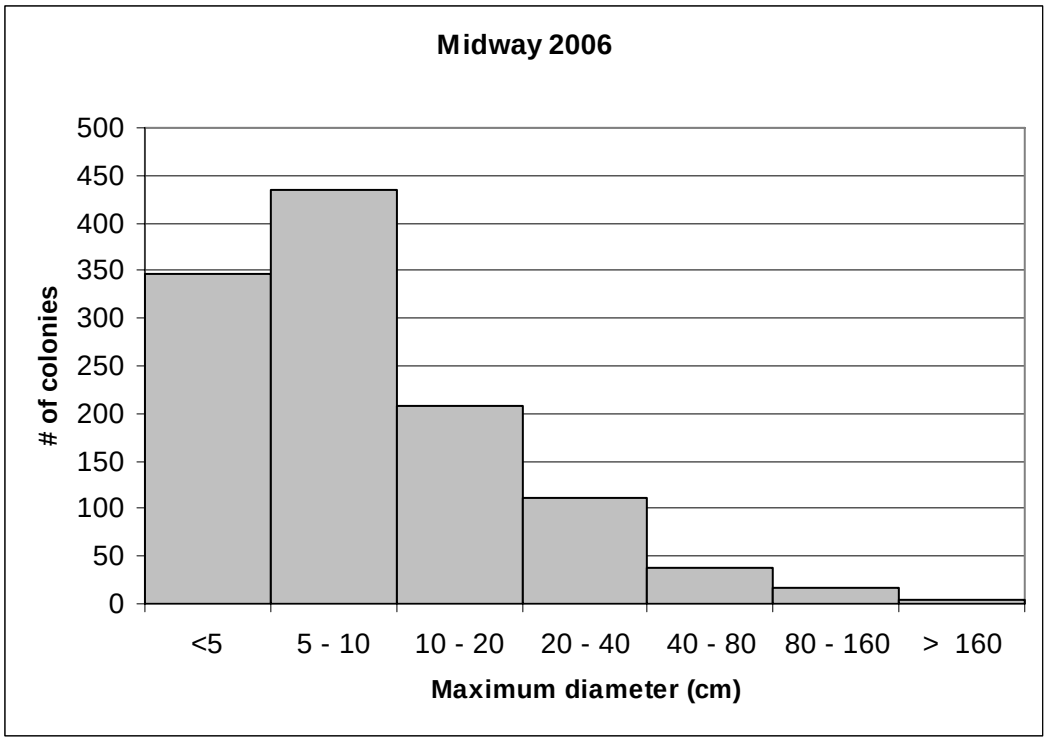

Figure I.3.2.1. Size class distribution of 1158 coral colonies enumerated within belt transects at Midway in 2006.

I.3.2.2. Percent benthic cover

Percent benthic cover surveys at Midway Aroll were conducted in congruency with the fish, coral population, and algae REA surveys, at nine sites. At Midway Atoll, point-intercept, live coral cover surveys were conducted along a total of 429 m of coral reef communities, including the southern forereef habitats, northern and eastern backreef environments, as well as central lagoon patch reefs. At one site (MID-3) survey transects extended for 27 and 33 m only; there were the diameter spans of the two patch reefs studied. The point-intercept surveys indicated that mean coral cover for all sites combined at Midway atoll was 13.6%. Out of the total of 12 scleractinain taxa observed for all sites combined, only 6 of these were enumerated along the line transect (Table I.3.2.2.1), with *Montipora flabellata* alone accounting for nearly 70% of all coral live cover. This species was particularly abundant at sites MID-1 and MID-H21 where it represented 52 and 27% of the benthic cover, respectively. *Porites lobata* and *Pocillopora meandrina* were second and third, in order of importance; these species were relatively abundant at sites MID-R7 and -R3, as well as MID-H11, respectively. Turf algae growing over carbonate pavement, dead coral surfaces, and coral rubble also accounted for a substantial portion of the biological benthos (68.3%). Table I.3.2.2.1 provides a complete list of percent cover of the different benthic elements enumerated using the point-intercept methodology at Midway Atoll. Figure I.3.2.2.1 illustrates the contribution of the different scledractinain taxa to the total percent of live coral cover

Table I.3.2.2.1 Percent cover of the benthic elements at Midway Atoll using the point-intercept method during the 2006 REA activities.

Species	Total	% cover
Cyphastrea ocellina	1	0.1
Montipora flabellata	82	9.4
Pocillopora meandrina	12	1.4
Porites compressa	2	0.2
Porites lobata	21	2.4
Psammocora stellata	1	0.1
Macro-algae	40	4.6
Coralline algae	1	0.1
Pavement/cca	1	0.1
Pavement/turf	421	48.1
Rubble	22	2.5
Rubble/cca	2	0.2
Rubble/turf	83	9.5
Dead/cca	5	0.6
Dead/lobo	7	0.8
Dead/turf	94	10.7
Sand	74	8.4
Other (Echinoderms)	7	0.8

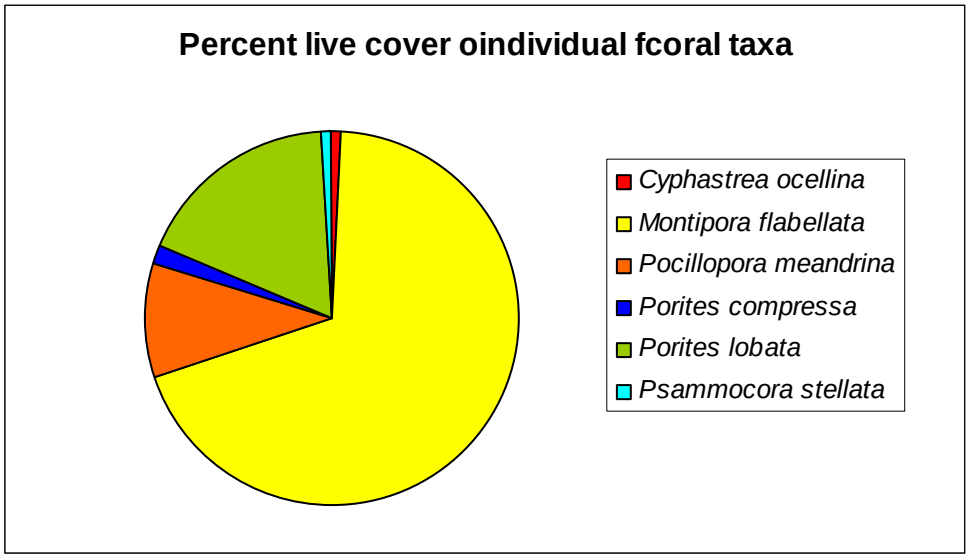

Figure I.3.2.2.1. Percent contribution of the different taxa to the total live coral cover.

I.3.2.3. Coral disease

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Psammocora stellata	1	0.1
Macro-algae	40	4.6
Coralline algae	1	0.1
Pavement/cca	1	0.1
Pavement/turf	421	48.1
Rubble	22	2.5
Rubble/cca	2	0.2
Rubble/turf	83	9.5
Dead/cca	5	0.6
Dead/lobo	7	0.8
Dead/turf	94	10.7
Sand	74	8.4
Other (Echinoderms)	7	0.8

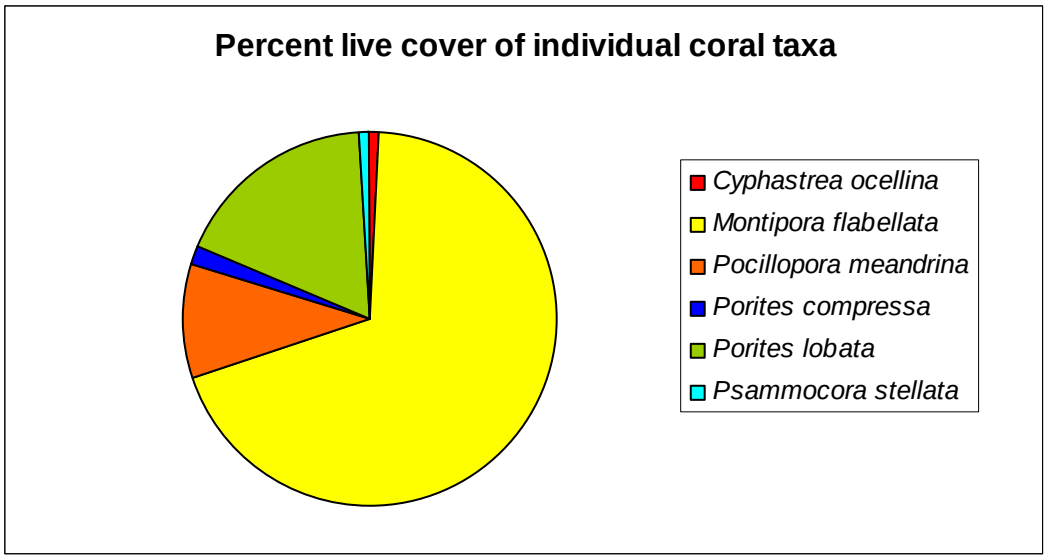

Figure I.3.2.2.1. Percent contribution of the different taxa to the total live coral cover.

I.3.2.3. Coral disease

The coral disease REA surveyed a total area of approximately 2275 m^2 at nine different sites during our visit to Midway Atoll. All together, however, scleractinian corals at Midway Atoll exhibited both lesser types of afflictions as well as number of disease cases than corals at Kure Atoll. During the HI0401, 2004 RAMP cruise, Drs. Kenyon and Aeby reported the occurrence of significant bleaching, particularly notable on *Montipora capitata* and *Pocillopora meandrina* along backreef and patch reef sites. In 2006, according to Kenyon (pers. comm.), it appears that much of the previously bleached corals died and are now colonized by turf algae, or in some cases replaced by *Montipora flabellata* or *Porites compressa*. Also, in 2004 Dr. Aeby reported five different coral diseases at Midway Atoll including *Porites* trematoidiasis, *Porites* tissue loss, *Porites* dark tissue thinning, *Montipora* tissue loss, and *Montipora* white spots. During our 2006 RAMP, we detected only one main type of coral disease (Table I.3.2.3.1); this was tissue loss, observable on three colonies of *Montipora flabellata* and three colonies of *Porites lobata*. On *M. flabellata*, tissue loss lesions were focal and radiated no more than 10 cm in diameter. On two cases, lesions were recent, exhibiting modest turf-algae colonization. It is plausible that these lesions may ultimately be predation marks; however, at time of survey, no predators or damselfishes were observed associated or in the vicinity of these lesions. Additionally, one case of bleaching was detected on one colony of *Montipora* cf. *capitata*. This colony occurred outside the survey plot on a sand plain; sand scouring and elevated turbidity could be contributors to pigmentation loss on this coral.

Equally important were also the 21 cases of compromised health condition observed (Table I.3.2.3.1). Within this health category, four sets of gross morphologies were identified, including: (1) discoloration (dark spots), mainly affecting colonies of *Porites lobata*; (2) focal to diffuse discoloration/pallor in concert with partial mortality and algal overgrowth affecting colonies of *Pocillopora meandrina*; (3) extensive corallivory and algal overgrowth observed on one large colony of *Porites lobata*; and (4) pigmentation responses

in concert with filamentous algal overgrowth on colonies of *Porites* spp. Tissue samples for histological analyses were procured, including samples of tissue loss on *Montipora flabellata* and bleaching on *Montipora* cf. *capitata*. At a future date, histological examination of tissues will be used to confirm specific disease etiology.

Table I.3.2.3.1 Compromised health conditions.

Type of disease	Species	Total
Tissue loss	*Montipora flabellata*	3
	Porites lobata	3
Compromised health state	*Species*	Total
Discoloration	*Porites lobata*	4
Discoloration and partial mortality	*Pocillopora meandrina*	3
Predation	*Porites lobata*	1
Pigmentation response	*Porites cf. solida*	1
	Porites lobata	6
Grand Total Cases		21

Figure I.3.2.3.1 illustrates the cumulative number of cases of disease conditions and compromised health states enumerated for all survey areas combined at Midway Atoll during the 2006 RAMP cruise. In addition, below, Figure 3.2.3.2 illustrates an itemized breakdown of the taxa exhibiting disease and compromised health states. At a future date, these data will

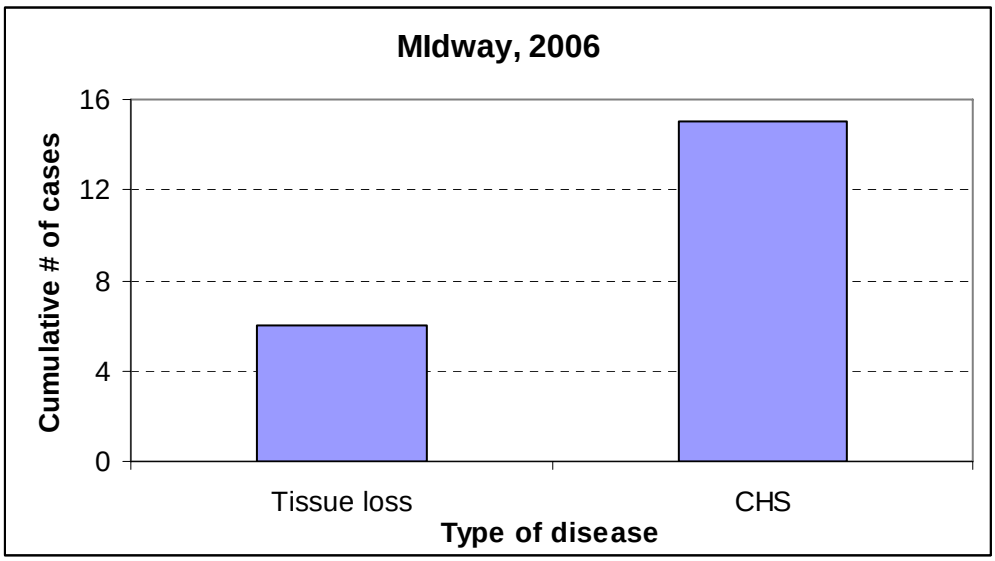

Figure I.3.2.3.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at Midway Atoll during the 2006 RAMP cruise. CHS: compromised health state.

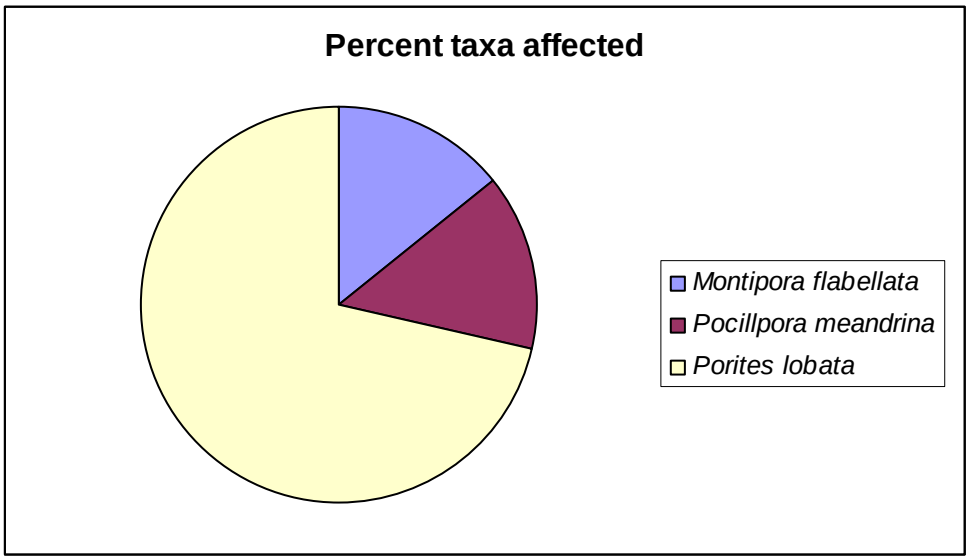

Figure I.3.2.3.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at Midway Atoll, 2006. CCA: crustose coralline algae.

be related to coral colony densities and coral cover in order to estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

I.3.2.4 USFWS permanent coral transects

Eleven permanently marked transects were established at Midway Atoll National Wildlife Refuge between 2000 and 2006, and all but two were relocated, repaired, and resurveyed in September 2006. One site, MID-13P, was again not relocated as a result of faulty GPS coordinates and was abandoned, although the REA team decided to establish a permanent transect at those coordinates. Another site, MID-1Pc, was not surveyed because of time constraints. Two of the resurveyed sites are situated on the eastern backreef of the atoll (MID-1Pa and -17P), two on the northeastern backreef (MID-2P and -8P), two on the northern back reef (MID-16P, -20P), one near the southwestern reef crest (MID-19P), one in the central lagoon finger coral gardens (MID-14P), and one near the southeastern boundary of the lagoon and backreef at the old CREWS buoy site (MID-7P). Unfortunately, the data from the 2000 surveys for sites MID-1P and -2P were not available on the cruise, nor were those of the 2002 survey at MID-7P. Thus, this analysis focuses on comparisons of the eight remaining transects between 2002 and 2006.

Overall coral populations showed mixed trends during the 4-year period. The abundance and numbers of *Porites lobata* generally declined while *P. compressa* increased slightly. The rose coral *Pocillopora* spp. showed no clear trends, and the abundance of *Montipora capitata* and *M.* cf. *turgescens* generally increased between 2002 and 2006. The small brain coral *Cyphastrea ocellina* and small branching coral *Psammocora stellata* were reported for the first time at several transects in 2006. Overall, there were no trends for coral

mean diameter or frequencies over the 4-year period, although generic diversity per transect increased at most sites.

Figures I.3.2.4.1 through I.3.2.4.8_ show the changes in size distribution for all corals at the eight sites for which the writer had data available on the ship. Eastern backreef site MID-1Pa showed increases at smaller size classes but declines in larger corals. Neighboring eastern backreef site 17P showed major declines in all size classes and genera. Although 2002 data were not available for the southeastern lagoon site at MID-7P at the old CREWS, the writer recalls large fingercoral colonies of *Porites compressa* dominating the site in 2002, which in 2006 were all dead but still largely intact. The southwestern reef crest/backreef site MID-19P also showed catastrophic declines in all corals. In contrast, the two northern backreef sites MID-20P and MID-16P dominated by *Montipora* showed major increases over the 4-year period, as did the northeastern backreef site at MID-18P. The writer's 2002 recollections suggest that the *Montipora* at these sites were especially hit hard with coral bleaching, but now have rebounded to levels comparable if not higher than those reported earlier. The reasons for the major coral declines at sites MID-7P, -1P and -17P are not clear but warrant continued monitoring.

Figures I.3.2.4.1 through I.3.2.4.8 . Plots of the size distribution of all corals for 2002 and 2006 at eight Midway Atoll permanent transect sites (after Maragos 2002, 2006 unpubl).

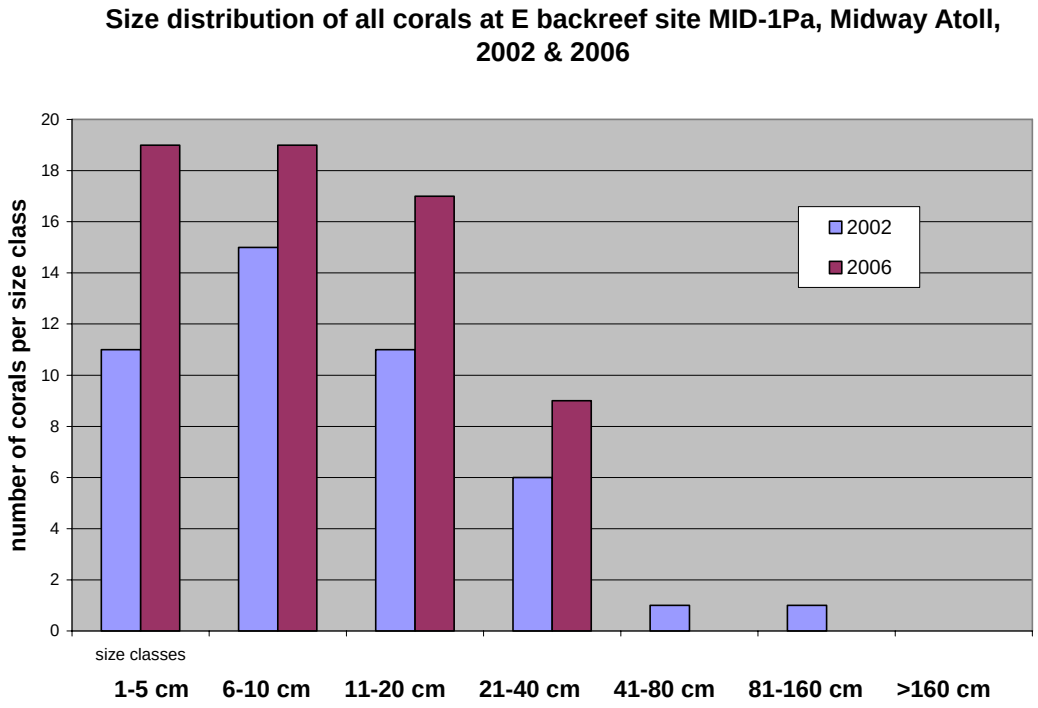

Figure I.3.2.4.1 Size distribution of all corals at Midway site MID-1Pa.

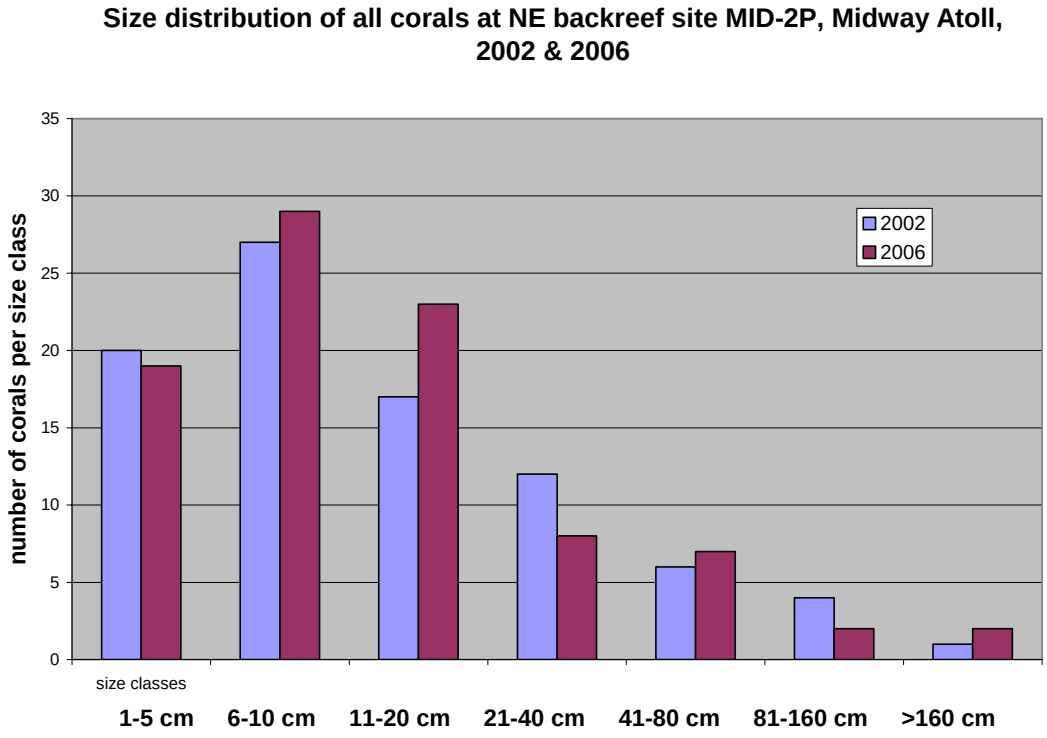

Figure I.3.2.4.2. Size distribution of all corals at Midway site MID-2P.

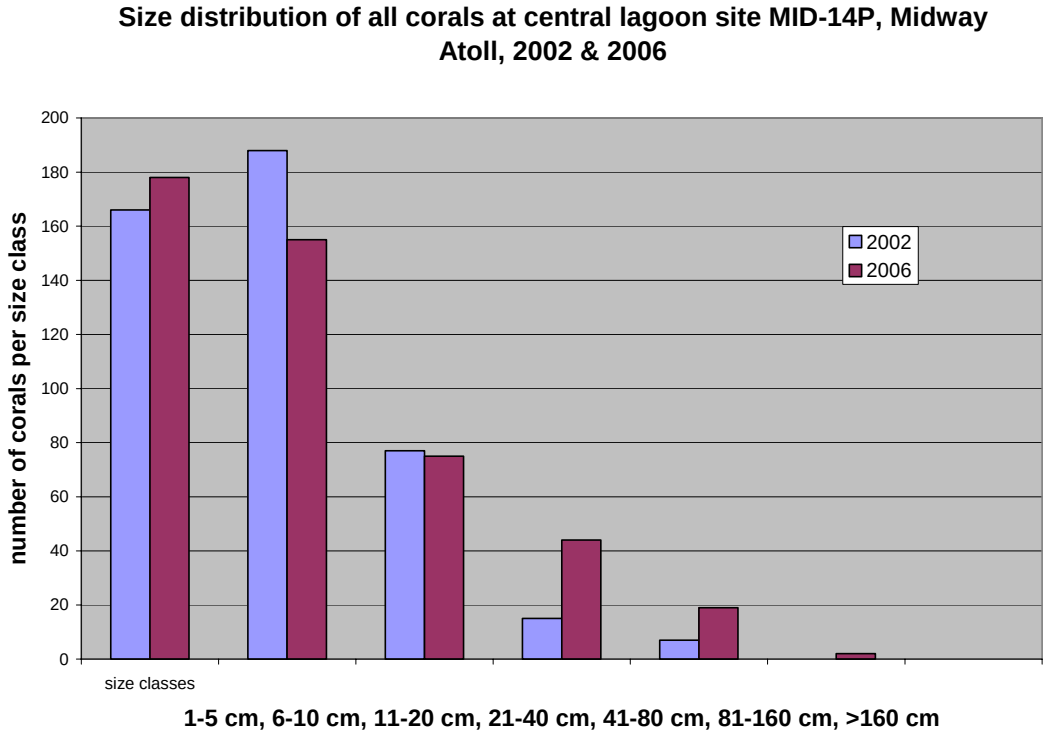

Figure I.3.2.4.3. Size distribution of all corals at Midway site MID-14P.

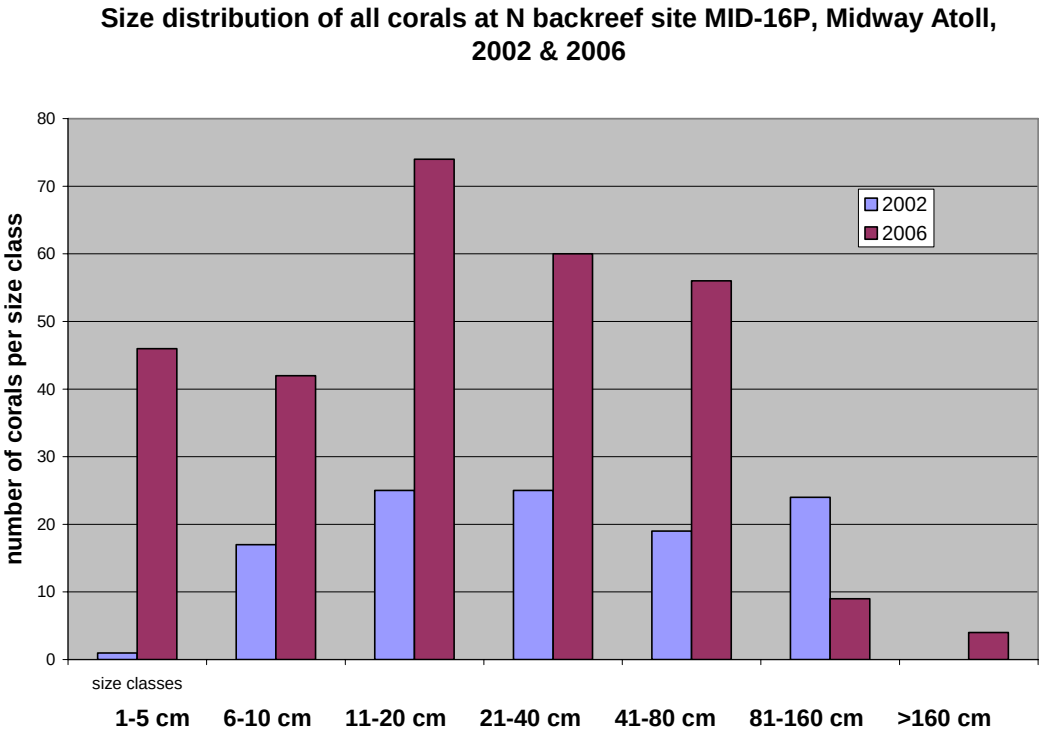

Figure I.3.2.4.4. Size distribution of all corals at Midway site MID-16P.

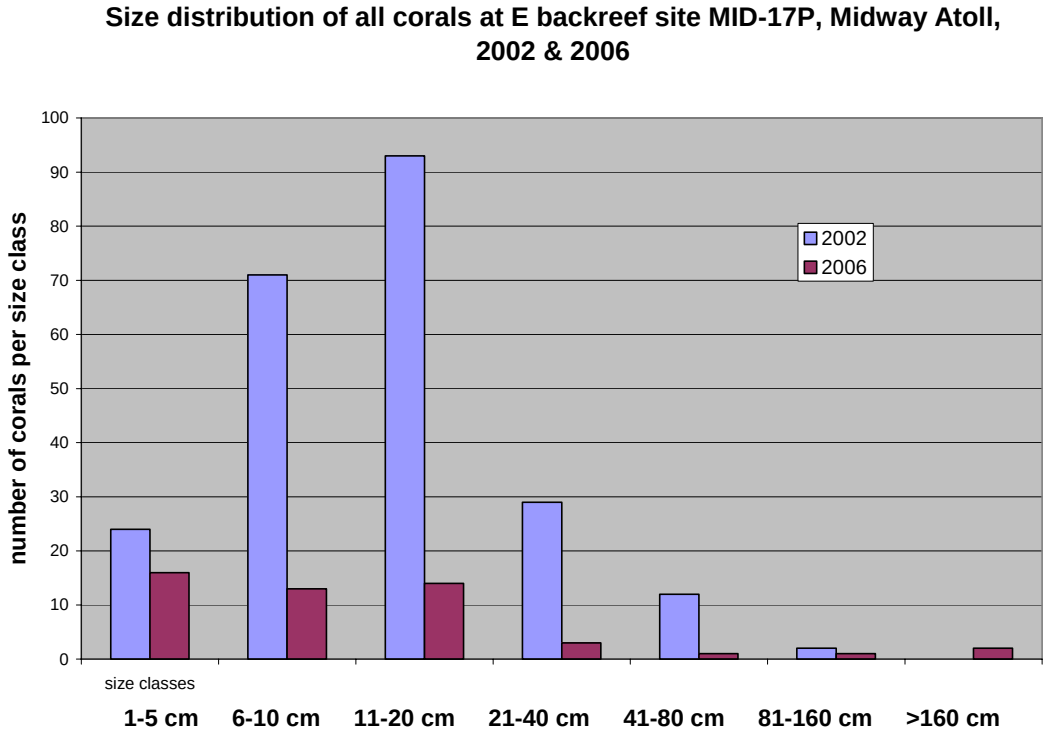

Figure I.3.2.4.5. Size distribution of all corals at Midway site MID-17P.

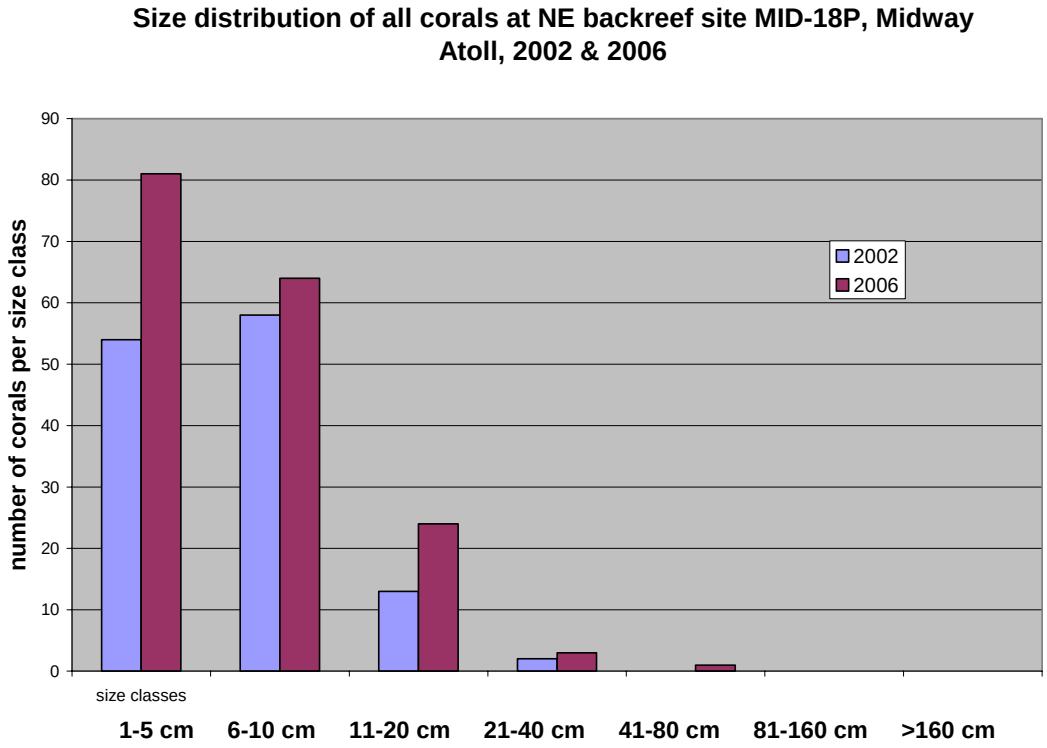

Figure I.3.2.4.6. Size distribution of all corals at Midway site MID-18P.

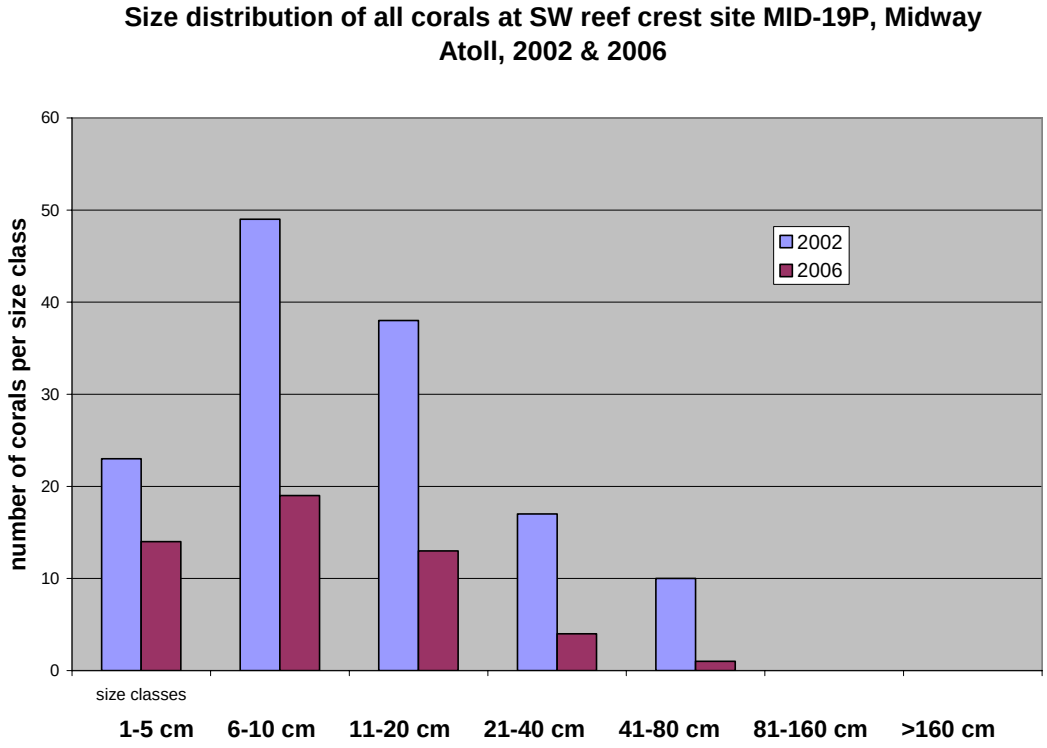

Figure I.3.2.4.7. Size distribution of all corals at Midway site MID-19P.

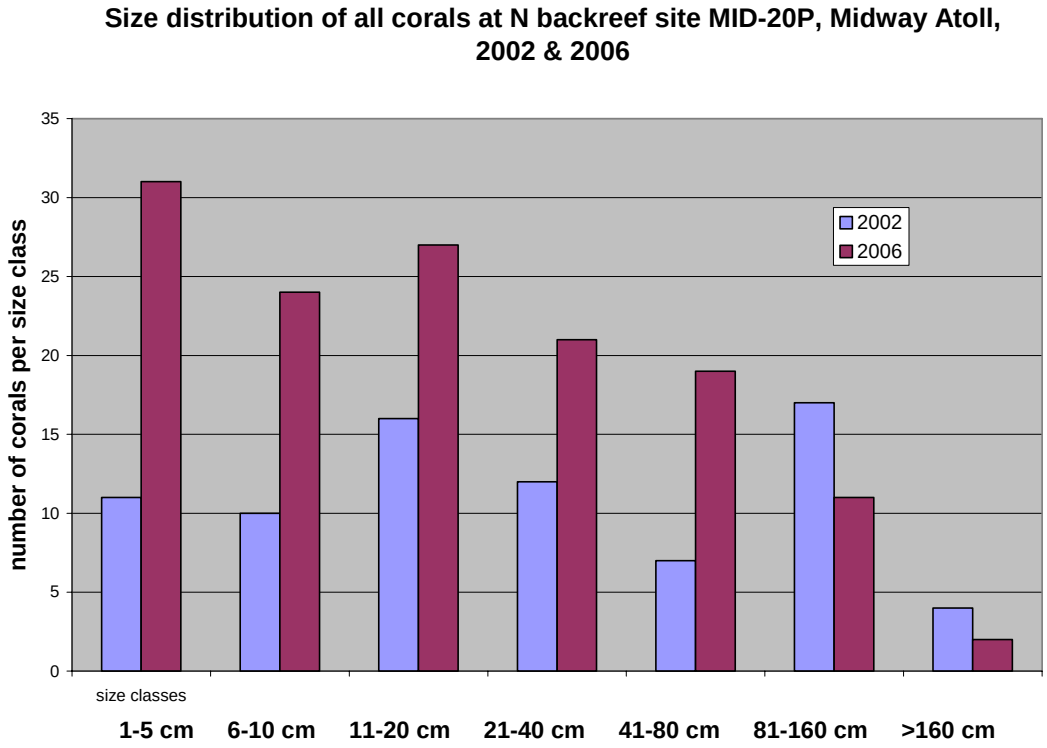

Figure I.3.2.4.8. Size distribution of all corals at Midway site MID-20P.

I.3.3 Towed-diver Benthic Surveys

Fifteen towed-diver surveys were conducted along the forereefs, backreefs, and lagoon of Midway Atoll. Habitat complexity was recorded as medium-high on the forereef, with the exception of the southern reefs outside of the channel (Fig. I.5.2, tow #2; medium complexity). Backreefs were recorded as medium-low to medium complexity, while the lagoon noted an overall medium complexity habitat.

During the eight surveys along the forereef, the habitat was primarily spur and groove/pavement reef, with the exception of the southern area outside of the channel, (Fig. I.5.2, tow #2) which was mostly bare pavement or large sand areas. The forereef cover averaged 1.3% hard coral, 1.5% macroalgae, and 3.6% coralline algae. The area surrounding the southern channel was marked by a number of large weights, wreckage, lines, and cables.

During the six backreef tows, the recorded habitat was primarily pavement reef with an abundance of turf algae in the midst of sand and rubble. Coral cover for the backreef averaged 1.5%, with localized increases of *Montipora* colonies along the northeast region (Fig. I.5.2, tow #9). Macroalgae averaged 5.1% during backreef surveys, with *Microdictyon setchellianum* as the dominant species. Coralline cover averaged less than 0.1%.

One towed-diver survey was conducted in the lagoon. The area had characteristics very similar to the backreef, primarily composed of turf (algae) covered pavement with areas

of sand and rubble. The coral cover averaged 0.1%, while the macroalgae and coralline algae cover was recorded as 16.0% and 0.6%, respectively.

Macroinvertebrate counts remained relatively constant throughout all towed-diver surveys, with a few notable exceptions. Sea urchins were highest along the southwestern forereef, averaging over 1,000 individuals per time segment (Fig. I.5.2, tow #4) and lowest along the northeastern backreef (Fig. I.5.2, tow #9; no time segment recording greater than 13 individuals). Sea cucumber counts remained consistently low throughout all surveys, with the highest numbers recorded along the eastern backreef (Fig. I.5.2, tow #12). Finally, six crown-of-thorns starfish were observed during all surveys at Midway.

I.4 Fish

I.4.1 REA Fish Surveys

SPC data

A total of 855 fishes of 32 species were seen in SPC surveys at the 9 Midway sites (95 fishes/dive), and 826 of the fishes (97%) were 50 cm or smaller. Most of the larger fishes were ulua, *Caranx ignobilis*, that were recorded on a single dive at site R31 (33 individuals 50 cm or larger counted). The most numerous fishes counted in SPCs at Midway overall were *Mulloidichthys flavolineatus* (250 individuals counted), *Kyphosus spp.* (196), and *Naso unicornis* (123).

BLT data

A total of 5465 fish were counted at the 9 sites on BLT transects. This reflects a fish density of 1.01 fishes/m^2. The most numerically abundant species were *Thalassoma duperrey* (842 individuals counted), *Mulloidichthys flavolineatus* (814 individuals counted), *Chromis ovalis* (771), *Stegastes fasciolatus* (505). Also relatively abundant were *Kyphosus spp.* (261), *Abudefduf abdominalis* (259), *Acanthurus triostegus* (232), and *Chromis hanui* (206). The size frequencies of all fishes counted are presented in Figure I.4.1.1.

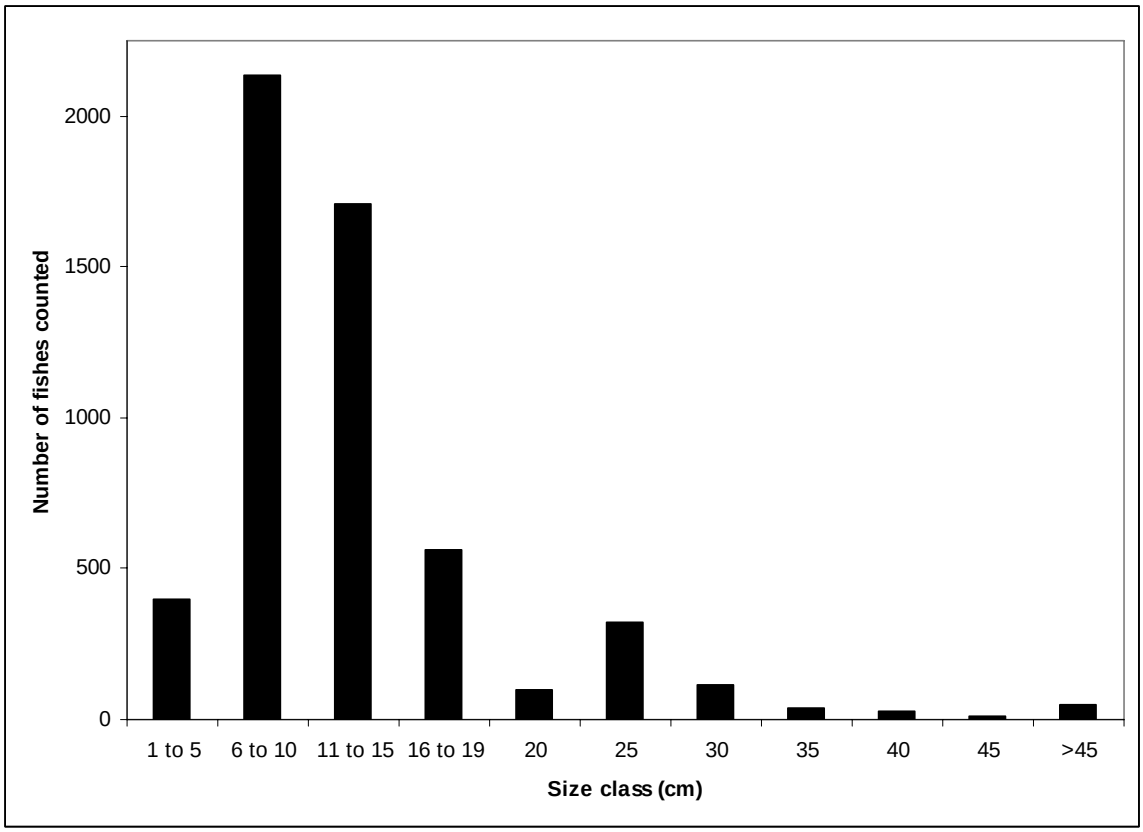

Figure I.4.1.1. Size frequencies of fish at Midway Atoll.

Forty-nine fishes larger than 45 cm were seen on BLT transects—most of them were ulua, *Caranx ignobilis* (30 individuals greater than 50 cm recorded).

Overall observations:

One hundred and forty-one total species were recorded from Midway Atoll. Compared to Kure, Laysan, and Necker, this island had the highest density of fishes on belt transects and the highest number of fish species recorded. There was a striking lack of sharks at our sites, and not very many uku, *Aprion virescens*, either (nine total counted in both belt transects and stationary point counts over nine dives). The main predator we saw was *Caranx ignobilis*, and these were only recorded from three of the nine dive sites. Presumably, we would have seen a more "apex-predator-dominated ecosystem" had we dove outside of the atoll more often. As it was, we would have to call it a "saddle-wrasse, goatfish, and herbivore-dominated ecosystem."

I.4.2 Towed-diver Fish Surveys

Table I.4.2.1. HI06_11 Towed-Diver Survey Report for Midway Atoll.

			Survey Length				Mean Depth
		N	Min	Max	Median	Sum	Median
Midway Atoll	**09/15/2006**	6	2.34	3.04	2.45	15.34	-10.47
	09/16/2006	5	1.82	2.62	2.17	10.82	-1.93
	09/21/2006	4	2.25	3.32	2.88	11.33	-10.37
	All	15	1.82	3.32	2.45	37.49	-8.63

N = number of surveys conducted.

Survey Length is given in kilometers.

Depth readings are taken at 5 sec intervals during each 50 min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of 22 species of large fishes (>50 cm TL) representing 13 families were observed at Midway Atoll during the survey period (09/15/06, 09/16/06, 09/21/06). The mean number of fishes (all species pooled) observed by divers was 0.24 ha-1 and the 20 mostly commonly recorded species are shown in Figure I.4.2.1. The spectacled parrotfish (*Chlorurus perspicillatus*) was the most abundant species observed during the quantitative surveys with a mean number of 3.45 fishes observed per hectare. The bigeye trevally (*Caranx sexfaciatus*) and green jobfish (*Aprion virescens*) were the next most abundant fishes behind the spectacled parrotfish with mean numeric densities of 1.04 ha-1 and 0.636 ha-1, respectively.

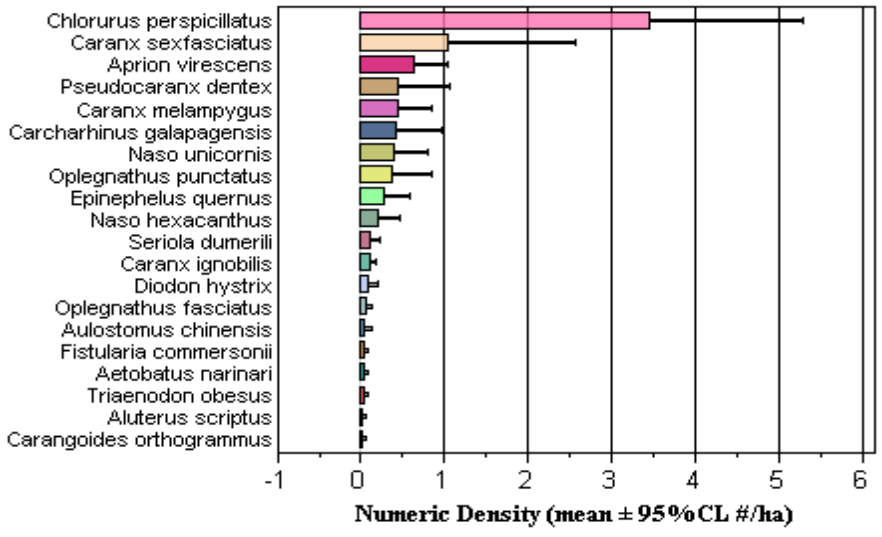

Figure I.4.2.1. The mean numeric density (number of fishes ha^{-1}) of the twenty most commonly observed fishes at Midway Atoll during the survey period.

The grand mean biomass density of fishes observed on the shallow reefs (<30 m) at Midway Atoll during the survey period was 1.71 x 10-3 t ha-1. The spectacled parrotfish (*Chlorurus perspicillatus*) and the Galapagos shark (*Carcharhinus galapagensis*) accounted for more than 61% of the total recorded fish biomass (Fig. I.4.2.2). The mean biomass density of spectacled parrotfishes was 1.72 x 10-2 t ha-1 and the mean biomass density of Galapagos sharks was 1.65 x 10-2 t ha-1. Galapagos sharks alone accounted for over 30% of the total recorded fish biomass.

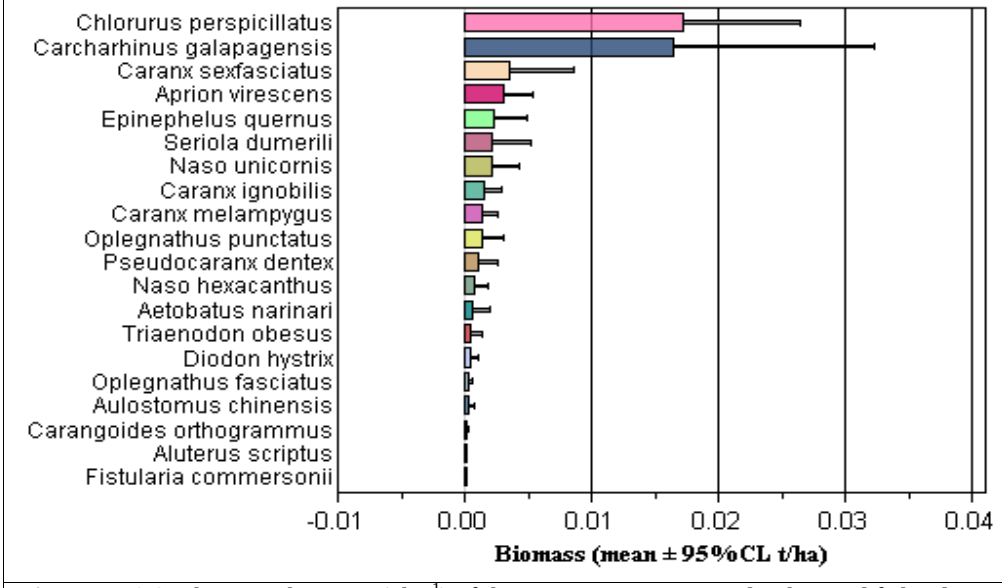

Figure I.4.2.2. The mean biomass (t ha^{-1}) of the twenty most commonly observed fishes larger than 50 cm (TL) at Midway Atoll during the survey period.

I.4.3 Shark Receivers

We recovered, downloaded, and redeployed three receivers (Table 1) and refurbished the ground tackle for two of these units (Fish Hole and Frigate Point). The old ground tackle was removed from the reef at these locations.

I.5 Maps

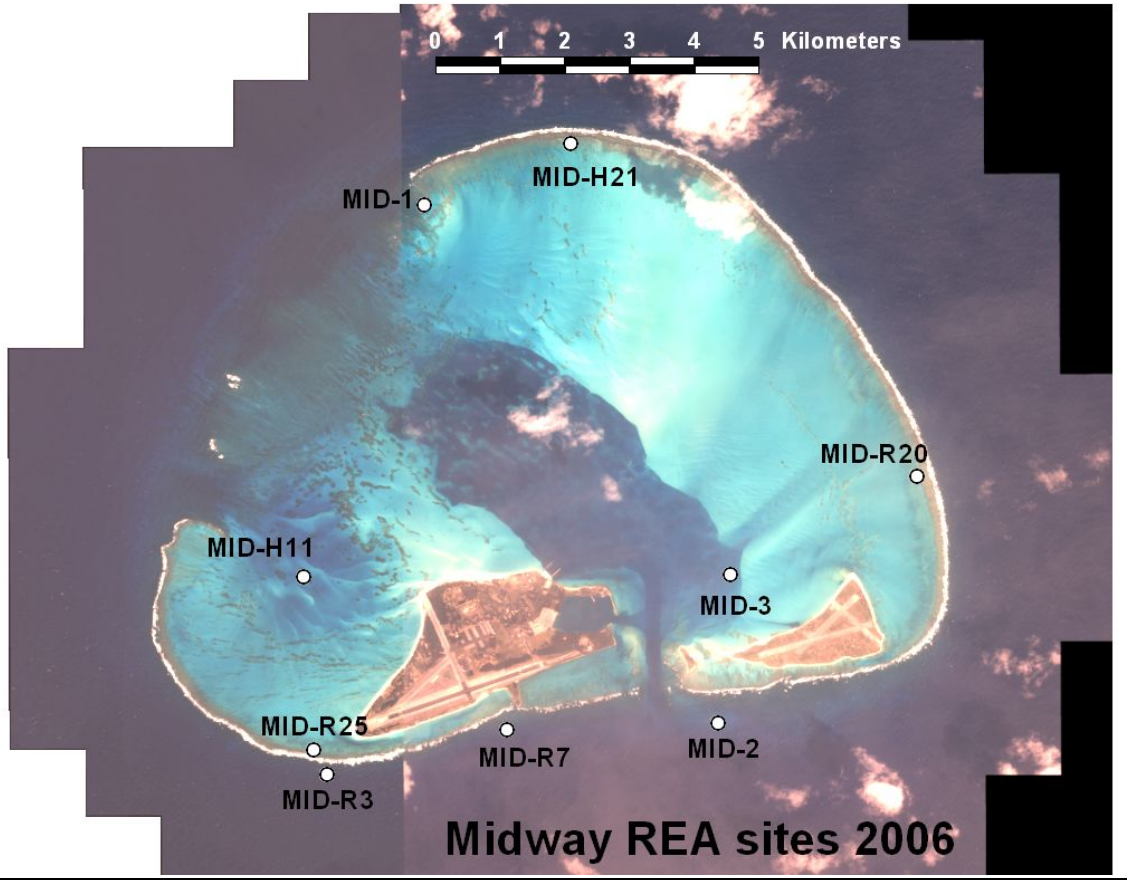

Figure I.5.1. Map showing location of 2006 Rapid Ecological Monitoring (REA) sites at Midway Atoll.

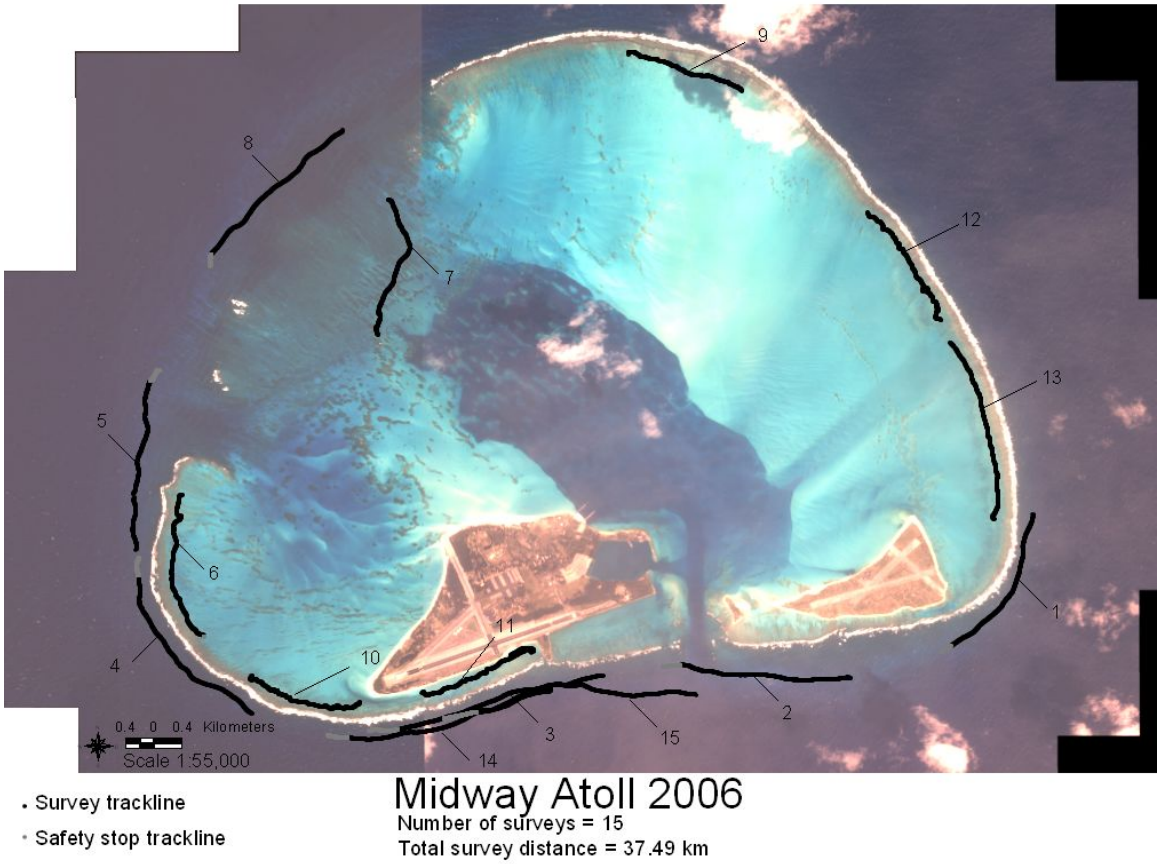

Figure I.5.2. Map showing location of towboard tracks at Midway Atoll.

Appendix J: Lisianksi Island/Neva Shoals

J.1. Oceanography and Water Quality

In total, eight instruments were deployed and five instruments were recovered at Lisianski Island and Neva Shoals. A sea surface temperature (SST) buoy and a subsurface temperature recorder (STR) were removed and replaced from a central point in Neva Shoals, south of Lisianski Island, in approximately 10 m water depth. One STR and one set of recruitment plates were recovered from an old Coral Reef Early Warning System (CREWS) buoy anchor, which because of environmental concerns, was also removed from this location. A new STR attached to the new SST anchor was deployed, replacing the STR recovered from the CREWS anchor. An additional STR was retrieved and replaced in shallow water (1 m) on the east side of Lisianski Island. Two wave and tide recorders (WTRs) were removed and replaced. The first was removed and replaced from the northwest side of the atoll in ~20 m depth. The second was removed from 15 m depth, replaced in about 20 m depth to allow improved comparison of the northern and southern wave fields, and to be consistent with those deployed at Kure (Mokupapapa) Atoll. This new location is within approximately 30 m of the old site. A new STR was attached to each of the WTR anchors, and a new STR was deployed at rapid ecological assessment (REA) site 16 in approximately 14 m of water. (See *Figure J.1.1.* for a map of all deployments.)

The retrieved WTRs were both Seabird 26plus pressure sensors with a sampling rate of 1200 second wave bursts at 2Hz, every 3 hours, with one tide sample every half hour. This gave a 1-year deployment limited by battery power. The northern WTR was a Seabird 26plus with alkaline batteries, while the southern instrument was the older Seabird 26 with lithium batteries. Since the newer instrument still had superior battery consumption, a higher frequency of sampling was considered of more importance on the more wave-energetic northern side of the atoll. The north WTR sampling scheme was set to 1200 second bursts every 4 hours, with one tide sample each hour, giving approximately two years sampling, time limited by battery power. The southern seabird 26 WTR sampling scheme was set at 1200 second bursts every 6 hours based on previous such deployments of seabird 26 with lithium battery upgrades.

A total of twenty conductivity, temperature, depth (CTD) casts were conducted around the perimeter of the reef system near the 30-m depth contour. Because of the extensive shallow shelf, some of the casts were conducted shallower than 30 m, the shallowest being 23 m. At four of these CTD casts, one at each of the major compass points, concurrent water samples measuring chlorophyll and nutrient levels were taken. Water samples were taken from the west, north, and east sides at 1 m, 10 m and 20 m, while sampling on the south side was performed at 1 m, 10 m, 20 m, and 30 m.

Preliminary results

Figure J.1.2. shows the temperature time series from the three temperature sensors retrieved during HI0611. Each of the sensors shows similar seasonal temperature fluctuations, with the warmest temperatures occurring from July to September and the

coolest from January to April. Deployed in the same location in central Neva Shoals, the SST buoy and the STR on the CREWS anchor (10 m depth) show consistently coincident temperature variations of comparable magnitudes. This suggests that the water column is well mixed in this exposed reef system; this was bolstered by the physical observation of strong currents and poor visibility at the deployment site. While the temperature graph from the STR deployed near the island shows similar seasonal variability, this record shows more high frequency fluctuations. This sensor was placed in a small cove and sheltered from major currents and mixing, hence, these fluctuations are likely a result of diurnal heating and cooling.

Data from the WTR retrieved from the northwest of the atoll could not be downloaded because of damaged connector pins. The WTR from the southeast of the atoll shows strong wave energy in the winter months and smaller pulses of wave energy during the summer months (Fig. J.1.3). Large winter wave events are likely driven by storms from the north to northwest which are refracting around the island, while long period summer swell is generated by southern hemisphere storm events. This data is similar to data collected at Kure (Mokupapapa) Atoll. This proposition will be confirmed by the northern sensor once the data has been retrieved by Seabird.

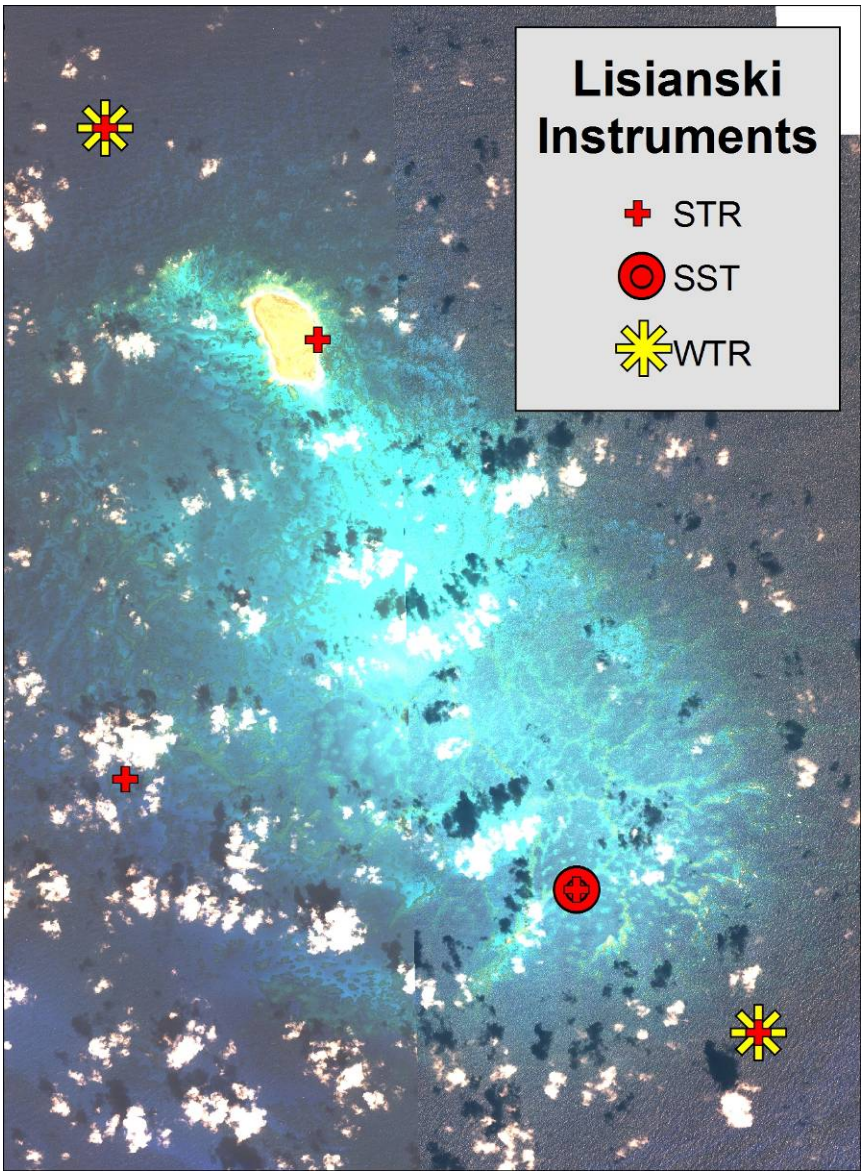

Figure J.1.1. IKONOS satellite image showing CRED oceanographic instrumentation deployed during HI0611.

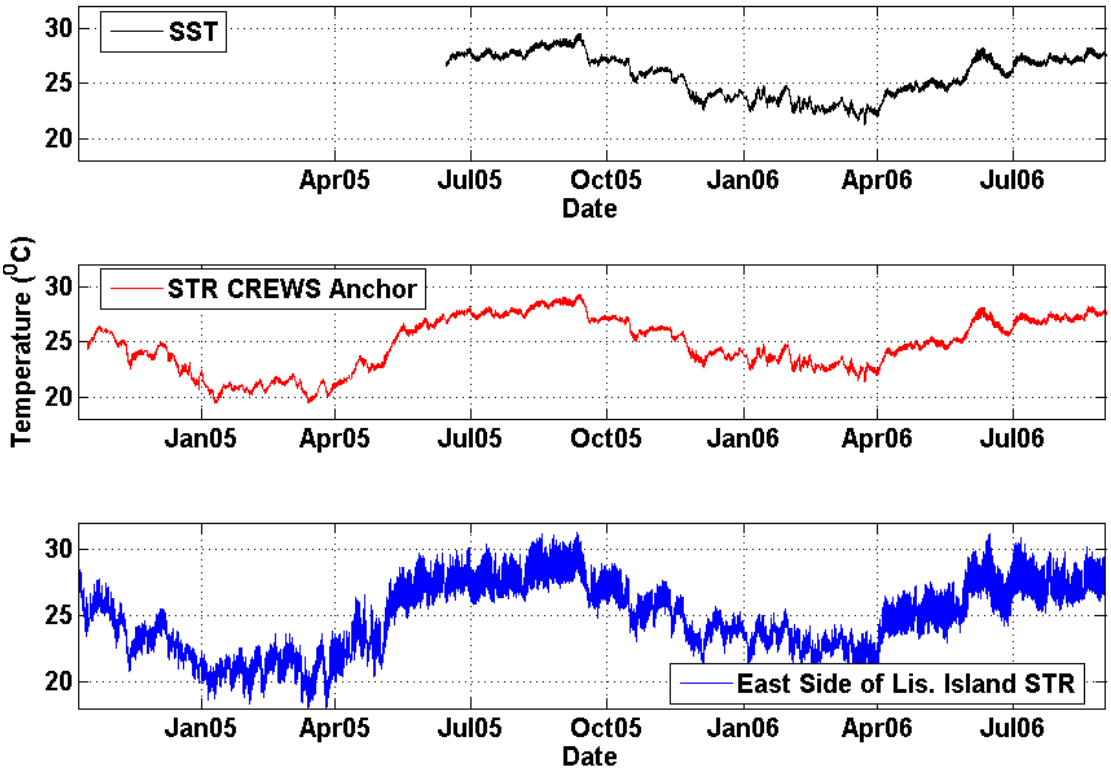

Figure J.1.2. Temperature time series from three temperature sensors. The SST and STR were at the same location, deployed on the surface and bottom (10 m), respectively. The STR was in 0.6 m off the south shore of Lisianski Island.

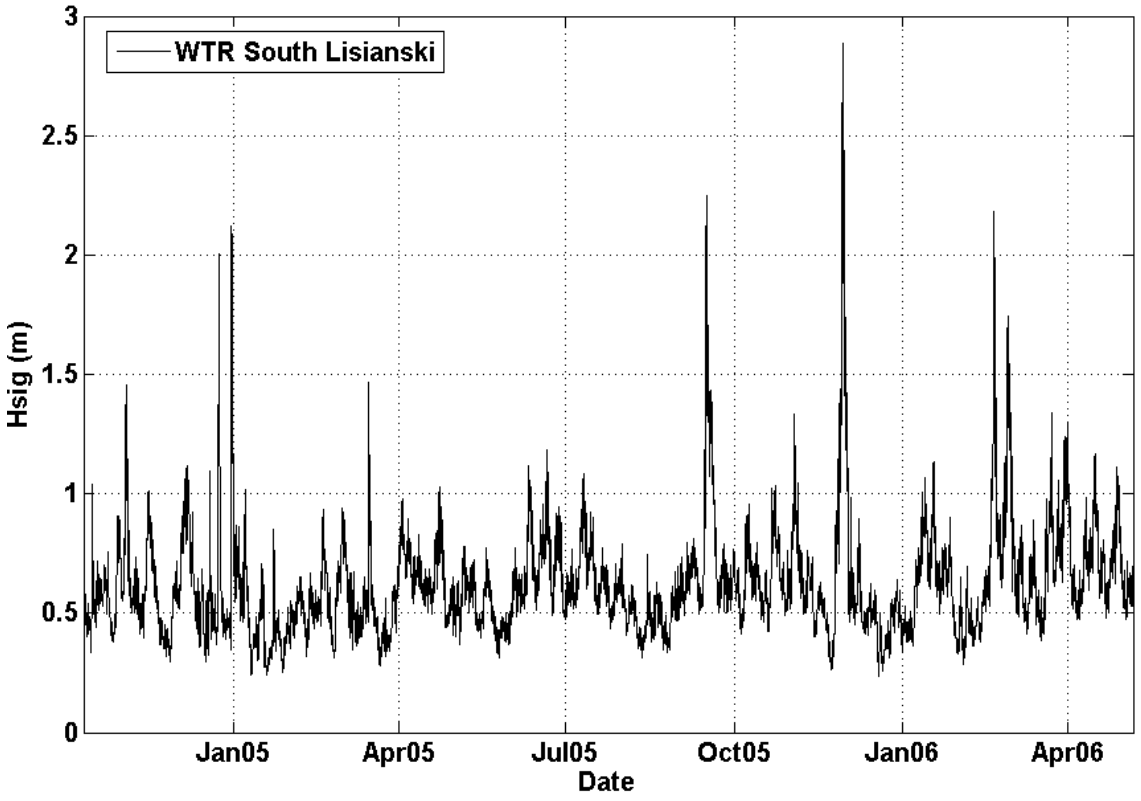

Figure J.1.3. Significant wave height from the Seabird 26plus retrieved from the southeast side of Papa'apoho (Lisianski) Atoll.

J.2. Rapid Ecological Assessment (REA) Site Descriptions

LIS-R14
September 25, 2006

West-northwest, backreef; depth range: 13–14.9 m. Visibility ~15 m. Installed new permanent transects (2, 25 m) This site was a coral-dominated reef system, but also contained a high degree of algal diversity. Turf algae, crustose coralline algae, non-geniculate calcified branched red algae, and *Halimeda velasquezii* were dominant, but cyanophytes, *Caulerpa taxifolia, C. webbiana*, *Halimeda opuntia*, *Microdictyon setchellianum*, *Lobophora variegata*, *Dictyosphaeria versluysii*, and species of *Neomeris*, *Peyssonnelia*, *Amphiroa*, and *Dictyota* were also found. Moderately high percent live coral cover (45%); dominated by fissioned colonies of *Porites lobata*. Other corals present along the line-intercept transects included: *Porites evermanni*, *Porites compressa*, *Montipora capitata,* and *Pavona duerdeni*. High coral cover, dominated by *Porites lobata, P. evermanni, P. compressa*. All well-pigmented, unlike 2004 when substantial bleaching esp. in *P. evermanni.* Nine scleractinian species enumerated within 50 m^2 belt transects. One additional scleractinian species (*Leptastrea purpurea*) observed in larger area outside belt transects.

Coral disease and health assessment: within the survey plot (150 m^2. Only transect 2 surveyed; there was not enough time to survey transect 1), 19 cases of bleaching were

observed on *P. lobata* and *P. evermanni*. In most cases, bleaching was focal and mild. Additionally, we observed two cases of tissue loss on *P. evermanni*, and three cases of trematodiasis on *Porites* spp. Finally, three cases of compromised health conditions were observed on *Porites* spp., involving multifocal discoloration. This site was heavy on the herbivores—surgeons and parrotfishes—especially *Acanthurus olivaceus, Acanthurus nigroris, Ctenochaetus strigosus, Scarus psitticus, Chlorurus sordidus,* and *Stegastes fasciolatus.* There were also quite a few *Thalassoma duperrey.* The stationary point count (SPC) diver saw lots of *Aprion virescens, Caranx ignobilis,* and large-ish *Chlorurus perspicillatus.* We also saw two Galapagos sharks and a white-tip reef shark.

LIS-12
September 25, 2006

West-northwest, spur-and-groove system on backreef; depth range: 7–8.2 m. Visibility ~15 m. Installed new permanent transects (2, 25 m). Sand groove and wall off-transect. This site was a beautiful example of an algal-dominated reef. Top of carbonate spur with heavy cover *Microdictyon, Halimeda,* and branching coralline algae. Mounds of both non-geniculate calcified branched red algae and species of *Peyssonnelia* grew amongst turf algae, cropped *Microdictyon setchellianum* beds, and curtains of *Halimeda velasquezii* and *H. opuntia*. Other algae found included *Dictyosphaeria versluysii, D. cavernosa, Lobophora variegata,* species of *Neomeris, Liagora,* and *Hypnea*. Additionally, an unidentified member of the Rhodymeniales was found. Low percent live coral cover (3.9%). Macroalgae, *Halimeda,* encrusting red algae, and calcified red algae comprised over 65% of the benthic cover. Eight scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Fungia scutaria* and *Pocillopora meandrina*) observed in larger area outside belt transects.

Coral disease and health assessment: within the survey plot (300 m^2), four cases of bleaching were observed on *P. lobata* and *P. evermanni*; analogous to site –R14, in most cases bleaching was focal and mild. Additionally, we observed one case of tissue loss on *P. compressa,* and one case of trematodiasis on *Porites lobata.* This site was dominated by *Thalassoma duperrey* and *Stegastes fasciolatus.* There were also quite a few *Acanthurus nigroris* around and quite a few other surgeons off of the transects. The SPC diver had *Caranx ignobilis* and *Caranx melampygus* accompanying him for most of the dive, and also saw *Aprion virescens, Chlorurus perspicillatus,* and *Scarus rubroviolaceus*.

LIS-R9
September 25, 2006

West-northwest, spur-and-groove system backreef; depth range: 7–15.2 m. Visibility ~15 m. Installed new permanent transects (2, 25 m). First transect crossed top of "spur" with low coral cover, abundant *Halimeda* and branching coralline algae; second transect crossed sandy "groove" with large *P. evermanni* colonies along sloping walls, resumed on top of next "spur." (IKONOS imagery reveals reefs are not really organized into spur and groove). The first transect at this site was on fairly level ground at ~8 m depth, but the second transect traversed a canyon that dipped to over 15 m. Turf algae, crustose coralline red algae,

Halimeda velasquezii, *H. opuntia*, *H. discoidea*, *Lobophora variegata*, non-geniculate calcified branched red algae, *Microdictyon setchellianum*, *Dictyosphaeria versluysii*, and species of *Neomeris* were common on the relatively flat areas. The deeper area also contained the above-mentioned mix of algal species, and also *Haloplegma duperreyi*, *Caulerpa taxifolia*, and species of *Peyssonnelia* and *Amphiroa* growing under rock overhangs on the sides of the canyon. Moderately low percent live coral cover (15.6%). Outstanding colonies of *Porites evermanni*. Macroalgae, *Halimeda*, encrusting red algae, and calcified red algae comprised over 40% of the benthic cover. Similarly, turf algae on coral and coralline pavement amounted for nearly 40% of the biological benthos. Low coral cover along first transect; moderate coral cover along second transect, dominated by *Porites lobata* and *P. evermanni*. All well pigmented, unlike 2004 when substantial bleaching occurred, esp. in *P. evermanni*. Eleven scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects.

Coral disease and health assessment: within the survey plot (300 m^2), eight cases of bleaching were observed on *P. lobata* and *P. evermanni*; analogous to the prior sites, for the most part, bleaching was focal and mild. Additionally, we observed two cases of tissue loss on *P. lobata*; one of these instances is possibly what Aeby named: *Portes* brown necrosis. Also two cases of trematodiasis on *P. evermanni* and *P. compressa*; and finally, one case of compromised health condition was observed on *Porites lobata*, involving multifocal discoloration (*Porites* discolored tissue thinning). This site had lots of *Thalassoma duperrey*, *Stegastes fasciolatus*, *Chlorurus sordidus*, and *Scarus psitticus.* There was a nice recruit population of *Stegastes fasciolatus* of 1-2 cm length. There were two to three *Caranx ignobilis* shadowing the belt divers, and the SPC diver had five large *Caranx ignobilis* accompanying him, along with several *Caranx melampygus.* The SPC diver also saw lots of large *Chlorurus perspicillatus*, *Monotaxis grandoculus*, and a fair few medium-size *Bodianus bilunulatus.*

LIS-18
September 26, 2006

West; backreef; moderate topographical relief, depth range: 6.4–8.8 m. Visibility ~9 m. Moderate surge. Installed new permanent transects (2, 25 m). Carbonate/sand with moderate coral cover. Shallow reef site dominated by turf algae, *Halimeda opuntia*, *H. velasquezii*, crustose coralline red algae, epiphytized *Microdictyon setchellianum*, and non-geniculate calcified branched red algae. Individuals of the following were common: *Martensia fragilis*, *M. flabelliformis*, cyanophytes, species of *Peyssonnelia*, *Dictyosphaeria cavernosa*, *D. versluysii*, *Dasya iridescens*, *Halimeda discoidea*, and species of *Neomeris*. Moderately low percent live coral cover (18.6%). Dominated by moderately fissioned *Porites lobata* and *P. evermanni*. Corals well-pigmented, unlike 2004 when substantial bleaching occurred. Eight scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Montipora capitata* and *Pocillopora meandrina*) observed in larger area outside belt transects. Only *Porites lobata* enumerated along the line-intercept transects. Macroalgae and *Halimeda* accounted for over 28% of the benthic cover. Similarly, turf algae on coral and coralline pavement amounted for nearly 50% of the biological benthos.

Coral disease and health assessment: within the survey plot (300 m^2), 10 cases of bleaching were observed on *P. lobata*; for the most part, bleaching was mild and focal. Additionally, one case of trematodiasis was observed on *P. lobata*. Finally, 20 cases of compromised health conditions were observed on *Porites lobata*, involving multifocal pigmentation responses (pink spots; not swollen, as opposed to trematodiasis) and discoloration. One tissue sample was procured of this pink-spot pigmentation response. This site was characterized by a surprising lack of parrotfish. There were an abundance of acanthurids, particularly *Stegastes* fasciolatus, and also a lot of *Thalassoma duperrey*. The SPC diver had several friendly *Caranx ignobilis* keeping her company, as well as a large white-tip reef shark. We also saw a leatherback, *Scomberoides lysan* at this location.

LIS-16
September 26, 2006

West; backreef; depth range: 8.8–11 m. Visibility ~9 m. Installed new permanent transects (2, 25 m). This reef was located next to a deep and wide sand channel and exhibited high coral cover and strong current. Quadrats were filled with turf algae, crustose coralline red algae, *Halimeda velasquezii*, *H. opuntia*, non-geniculate calcified branched red algae, *Dictyosphaeria versluysii*, *Microdictyon setchellianum* (usually cropped very short and highly epiphytized), an encrusting form of *Lobophora variegata*, cyanophytes, and species of *Peyssonnelia* and *Martensia*. An astounding specimen of *Gibsmithia hawaiiana* was also collected from the random swim along with species of *Neomeris* and *Nemastoma*. Strong current made work difficult and compromised coral population data. Dominated by moderately fissioned *Porites lobata*. Corals well pigmented, unlike 2004 when substantial bleaching occurred. Twelve scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects. Percent live coral cover was 32%, and *Porites lobata* represented over 70% of the scleractinians enumerated along the line-intercept transects. Other corals recorded along the transect lines included: *Montipora* cf. *capitata*, *Pavona duerdeni*, *Leptastrea purpurea*, and *Cyphastrea ocellina*.

Coral disease and health assessment: within the survey plot (150 m^2: only transect 2 surveyed for disease because of lack of time and strong surge and current), five cases of bleaching were observed on *P. lobata* and *Montipora* cf. *capitata*; for the most part, bleaching was mild and focal. Additionally, one case of tissue loss was observed on *P. lobata*. This case of tisse loss was unique in that exhibited yellow and gray discolorations in addition to the tissue loss. This was the first instance where this type of disease was observed on this cruise. Several samples were procured of healthy and diseased tissue. Finally, three cases of compromised health conditions were observed on *Porites lobata*, involving multifocal pigmentation responses (pink spots; not swollen, as opposed to trematodiasis) and discoloration. This site was composed of a lot of *Thalassoma duperrey* and *Stegastes fasciolatus.* There was a smattering of surgeonfishes, particularly *Ctenochaetus strigosus,* a good abundance of *Chlorurus perspicillatus,* and a large school of *Acanthurus triostegus* was observed off the transect. The SPC diver saw predominantly surgeonfishes and parrotfishes: *Naso unicornis, Acanthurus olivaceus,* and *Chlorurus sordidus.*

LIS-17
September 26, 2006

West; backreef; high topographic relief ,depth range: 8.8–12.4 m. Visibility ~5-7 m. Installed new permanent transects (2, 25 m). This site had extremely poor visibility, but was a pretty reef with lots of topography. Scleractinian coral species dominated many of the quadrats sampled for algae. The algal community was characterized by non-geniculate calcified branched red algae, turf algae, crustose coralline red algae, *Halimeda velasquezii*, and *H. opuntia*. Occasional patches of *Martensia fragilis* were observed, along with individuals of encrusting *Lobophora variegata*, *Halimeda discoidea*, *Dasya iridescens*, *Caulerpa taxifolia*, and species of *Neomeris*, *Peyssonnelia*, and *Nemastoma*. Percent live coral cover was relatively high: 43%. The coral community was mainly composed of an amalgam of *Porites lobata*, *P. evermanni*, *P. compressa*. These three species were recorded along the point-intercept transect and represented over 80% of the scleractinians enumerated. Numerous pinnacles of *Porites evermanni*/branched coralline algae, with partial mortality of *P. evermanni* and colonization of dead substrate by diverse other coral colonies. Corals well pigmented, unlike 2004 when substantial bleaching occurred. Thirteen scleractinian species enumerated within 50 m^2 belt transects. No additional anthozoan species observed in larger area outside belt transects. Other corals recorded along the transect lines included *Montipora* cf. *capitata*, *Pocillopora damicornis*, and *Cyphastrea ocellina*.

Coral disease and health assessment: within the survey plot (300 m^2), 13 cases of bleaching were observed on *P. lobata*, *P evermanni*, and *Montipora* cf. *capitata*; analogous to the prior sites, bleaching was mostly mild and focal. One of the colonies of *P. evermanni* presenting bleaching also exhibited a growth anomaly; the first one observed throughout this cruise. Additionally, one case of trematodiasis was observed on *P. lobata*. Finally, four cases of compromised health conditions were observed on *Porites evermanni*, involving multifocal pigmentation responses (non-swollen pink spots, as opposed to trematodiasis). This site had a lot of very small surgeonfish recruits, predominantly *Zebrasoma flavescens* and *Ctenochaetus strigosus.* There were quite a few *Mulloidichthys flavolineatus* about, as well as the omnipresent *Thalassoma duperrey.* The SPC diver saw primarily *Caranx ignobilis, Caranx melampygus,* and *Aprion virescens.*

LIS-R7
September 27, 2006

West-southwest; backreef; moderately high topographical relief depth range: 9.7–14 m. Visibility ~30 m. New permanent transects (2, 25 m) installed. This was a beautiful reef setting with high *Porites* and *Montipora* cover. Most of the algal community occurred at the base of living coral branches or between fingers of coral. We recorded turf algae, extensive tufts of a species of *Neomeris*, *Dictyosphaeria cavernosa*, *Lobophora variegata*, *Halimeda velasquezii*, *H. opuntia*, crustose coralline red algae, non-geniculate calcified branched red algae, *Dasya iridescens*, *Caulerpa webbiana*, *Gibsmithia hawaiiensis*, *Caulerpa serrulata*, *Caulerpa taxifolia*, cyanophytes, and species of *Laurencia*, *Peyssonnelia*, and *Liagora*. High percent live coral cover (69.6%); splendid combination of *Porites lobata*, *P. compressa*, and *P. evermanni*. Gradient of growth forms sometimes made

it difficult to distinguish between the two species of *P. evermanni* and *Porites lobata,* and colonies were moderately fissioned; counts for these taxa therefore highly interpretive. Corals well pigmented, unlike 2004 when substantial bleaching especially in *P. evermanni*. Eleven scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Leptastrea purpurea* and *Psammocora stellata*) observed in larger area outside belt transects. *Montipora capitata* and *M. patula* also enumerated along the point-intercept transects.

Coral disease and health assessment: within the survey plot (300 m^2), 11 cases of bleaching were observed on *Porites* spp. and *Montipora capitata*; for the tissue loss were observed on *P. lobata* and *P. evermanni*. One tissue sample was procured from a case of tissue loss also exhibiting tissue discoloration. Finally, 26 cases of compromised health conditions were observed on *Porites* spp., involving multifocal pigmentation responses (pink spots; not swollen, as opposed to trematodiasis) and discoloration. This was a very nice dive site. The belt transects were dominated by *Chromis hanui, Stegastes fasciolatus,* and *Thalassoma duperrey.* Transect C had the best diversity overall. SPC diver saw lots of large *Caranx ignobilis, Chlorurus perspicillatus,* and an abundance of large *Acanthurus olivaceus.* Two divers saw thousands of very small juvenile *Chlorurus sordidus,* and there was also a large roving school of *Acanthurus triostegus* mixed with *Acanthurus olivaceus,* and also a large school of *Chromis ovalis.* Two Galapagos sharks were also seen, and some friendly *Aprion virescens* were around.

LIS-R10
September 27, 2006

West-southwest; backreef, moderately high topographical relief bank reef; depth range: 10–14.6 m. Visibility ~15 m. Spur-and-groove system. This site exhibited high coral cover and was remarkable for the massive (and presumably very old) colonies found. Much of the algal population occurred at the base of living coral branches or between fingers of coral. We recorded turf algae, extensive tufts of a species of *Neomeris, Lobophora variegata, Halimeda velasquezii, H. opuntia, H. discoidea*, crustose coralline red algae, non-geniculate calcified branched red algae, *Caulerpa serrulata*, and *Caulerpa taxifolia*. Relatively high percent live coral cover (50%); composed of a combination of *Porites lobata*, *P compressa*, and *P. evermanni*. These three species comprised over 70% of the scleractinian taxa. Abundant encrusting *Montipora patula* and *M. capitata* on some sections of transect belt. Corals well pigmented, unlike 2004 when substantial bleaching especially in *P. evermanni***.** Huge *P. evermanni* bommies in area. Ten scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Fungia scutaria* and *Pocillopora eydouxi*) observed in larger area outside belt transects. Other coral recorded along the point-intercept transects included: *Cyphastrea ocellina*.

Coral disease and health assessment: within the survey plot (300 m^2), eight cases of bleaching were observed on *Porites lobata* and *P. evermanni*, three cases of growth anomalies on *Montipora capitata*, and *M. patula*, as well as one case of tissue loss on *P. evermanni*. One tissue sample was procured from a case of tissue loss also exhibiting tissue

discoloration. Finally, two cases of compromised health conditions were observed on *Porites* spp., involving focal discoloration (dark spots and pallor). This site was dominated by planktivores and herbivores, such as *Chromis ovalis, Chromis vanderbilti, Chlorurus sordidus, Stegastes fasciolatus, Acanthurus leucopareius* and *Ctenochaetus strigosus.* There were also quite a few *Thalassoma duperrey, Thalassoma ballieui,* and *Stethojulis balteata.* SPC diver saw a couple of *Aprion virescens,* but mostly counted parrotfishes (*Chlorurus sordidus, Chlorurus perspicillatus*). There were several large *Caranx ignobilis* cruising around, and we saw *Pseudojuloides cerasina* and *Epibulus insidiator.*

LIS-10
September 27, 2006

West-southwest; southeast backreef, moderate topographical relief; depth range: 8.5–11.3 m. Visibility ~10 m. Spur-and-groove system. New permanent transects installed (2, 25 m). This reef exhibited extensive cover of species of *Porites*. Visibility was low. Inside photoquadrats we recoreded turf algae, *Halimeda velasquezii, H. opuntia, H. discoidea, Dictyosphaeria versluysii, Lobophora variegata, Caulerpa taxifolia,* crustose coralline red algae, a species of *Neomeris,* and cyanophytes. *Dasya iridescens, Bryopsis pennata, Dictyosphaeria cavernosa,* and a species of *Martensia* were collected during the random swim. Percent live coral cover was comparable to site R-10 (50%). Similalry, *Porites lobata, P compressa,* and *P. evermanni* dominated this; these three species comprised over 80% of the scleractinian taxa. Impressive (over 2.0 m diameter) bommie of *Porites evermanni.* Dominated by moderately-fissioned *Porites compressa* and *P. evermanni*, with areas of encrusting *Montipora capitata* and *M. patula*. Corals well pigmented, unlike 2004 when substantial bleaching occurred, especially in *P. evermanni*. Eleven scleractinian species enumerated within 50 m^2 belt transects. Two additional scleractinian species (*Fungia scutaria* and *Psammocora stellata*) observed in larger area outside belt transects. Other coral recorded along the point-intercept transects included: *Pavona duerdeni,* and *Pocillopora damicornis.*

Coral disease and health assessment: within the survey plot (300 m^2), 13 cases of bleaching were observed on *Porites* lobata, *P. evermanni*, and *Montipora capitata*. On colonies of *Porites,* bleaching was, for the most part mild and focal. Contrastingly, on *Montipora capitata,* bleaching was moderate to marked, and diffuse. No additional afflictions to corals or coralline algae were encountered at this site. This murkorific site had the most aggressive *Caranx ignobilis* we have seen thus far. The belt transect (BLT) divers saw *Stegastes fasciolatus, Thalassoma duperrey,* and *Ctenochaetus strigosus* in abundance. SPC diver saw a lot of *Caranx ignobilis,* and had 12 of them circling him closely on replicate 4.

J.3. Benthic Environment

J.3.1. Algae

Quantitative algal surveys were conducted at nine sites on the northwestern and southwestern sides of Lisianski Island/Neva Shoals (LIS-R-14, LIS-12, LIS-9, LIS-18, LIS-16, LIS-17, LIS-R-7, LIS-R-10, LIS-10). Most of the surveys conducted by the REA team took place on bank reefs: some exhibiting spur-and-groove topographies, and others less complex topographies. Green algae were very common at all sites, especially *Halimeda opuntia, H. velasquezii*, *H. discoidea*, *Dictyosphaeria versluysii*, *D. cavernosa, Microdictyon setchellianum,* and species of *Neomeris.* Red algae were less common in abundance (although red algal diversity, especially among the turf algal community, is expected to far exceed green or brown algal diversity), but the following were commonly seen: *Asparagopsis taxiformis, Dasya iridescens*, *Gibsmithia hawaiiensis*, non-geniculate calcified branched red algae, crustose coralline red algae and species of *Amphiroa, Martensia*, and *Peysonnellia*. Other algae such as *Hypnea spp., Hapoglema duperrey,* and *Laurencia* spp. were only found at one site. Brown algae were fairly uncommon, although *Lobophora variegata* was collected from all sites. Overall, 11 species of green algae, 12 species of red algae, and 2 species of brown algae were collected. Once microscopic examination of samples occurs, it is expected that epiphytes identified will increase the number of species collected substantially.

Table J.3.1.1: Algal genera or functional groups recorded in photoquadrats at Lisianski Island/Neva Shoals. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	LIS-R-14	LIS-12	LIS-9	LIS-18	LIS-16	LIS-17	LIS-R-7	LIS-R-10	LIS-10
GREEN ALGAE									
Caulerpa	*16.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*
	4.5	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**
Dictyosphaeria	*0.0*	*16.7*	*25.0*	*8.3*	*16.7*	*0.0*	41.7	0.0	83.3
	0.0	**6.0**	**5.3**	**5.0**	**6.5**	**0.0**	5.0	0.0	2.8
Halimeda	*100.0*	*100.0*	*91.7*	*100.0*	*100.0*	*100.0*	*83.3*	*83.3*	*83.3*
	3.5	**4.6**	**4.1**	**2.8**	**4.0**	**3.3**	**2.9**	**3.1**	**2.8**
Microdictyon	*16.7*	*91.7*	*8.3*	*50.0*	*58.3*	*0.0*	*0.0*	*0.0*	*0.0*
	3.5	**2.2**	**6.0**	**3.2**	**4.4**	**0.0**	**0.0**	**0.0**	**0.0**
Neomeris	*16.7*	*8.3*	*8.3*	*0.0*	*0.0*	*0.0*	*33.3*	*16.7*	*16.7*
	5.0	**8.0**	**6.0**	**0.0**	**0.0**	**0.0**	**2.3**	**4.0**	**2.5**
RED ALGAE									
Amphiroa	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**5.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Asparagopsis	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**
Non-geniculate calcified branched red algae	*25.0*	*100.0*	*58.3*	*41.7*	*83.3*	*41.7*	*8.3*	*25.0*	*0.0*
	5.0	**2.9**	**4.3**	**4.4**	**4.3**	**1.6**	**4.0**	**3.7**	**0.0**

	LIS-R-14	LIS-12	LIS-9	LIS-18	LIS-16	LIS-17	LIS-R-7	LIS-R-10	LIS-10
crustose coralline algae	*100.0*	*0.0*	*83.3*	*91.7*	*91.7*	*91.7*	*75.0*	*100.0*	*66.7*
	2.5	**0.0**	**2.3**	**3.7**	**2.3**	**3.1**	**2.3**	**1.8**	**2.5**
Laurencia	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.5**	**0.0**	**0.0**
Martensia	*0.0*	*0.0*	*0.0*	*16.7*	*8.3*	*8.3*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**4.0**	**7.0**	**3.0**	**0.0**	**0.0**	**0.0**
Peysonnellia	*8.3*	*16.7*	*8.3*	*8.3*	*16.7*	*0.0*	*0.0*	*0.0*	*0.0*
	4.0	**4.5**	**3.0**	**5.0**	**5.5**	**0.0**	**0.0**	**0.0**	**0.0**
BROWN ALGAE									
Lobophora	*33.3*	*41.7*	*33.3*	*0.0*	*8.3*	*25.0*	*16.7*	*50.0*	*16.7*
	4.3	**6.8**	**4.5**	**0.0**	**5.0**	**4.7**	**4.0**	**3.5**	**3.5**
FUNCTIONAL GROUPS									
turf algae	*100.0*	*100*	*91.66*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
	1.2	**1.9**	**1.0**	**1.0**	**1.1**	**1.3**	**1.3**	**1.4**	**1.1**
cyanophytes	*0.0*	*0.0*	*0.0*	*8.3*	*33.3*	*0.0*	*16.7*	*8.3*	*8.3*
	0.0	**0.0**	**0.0**	**5.0**	**5.5**	**0.0**	**4.0**	**4.0**	**3.0**

Table J.3.1.2: Putative algal species found at Lisianski Island/Neva Shoals. All species will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae will be identified in the lab. All specimens will be deposited at Bishop Museum after analysis.

List of putative macroalgal species collected (one sample per site)

	LIS-R-14	LIS-12	LIS-9	LIS-18	LIS-16	LIS-17	LIS-R-7	LIS-R-10	LIS-10
GREEN ALGAE									
Bryopsis pennata									X
Caulerpa serrulata							X	X	
Caulerpa taxifolia	X		X			X	X	X	X
Caulerpa webbiana	X						X		
Dictyosphaeria versluysii	X	X	X	X	X				X
Dictyosphaeria cavernosa		X		X			X		X
Halimeda discoidea			X			X		X	X
Halimeda opuntia	X	X	X	X	X	X	X	X	X
Halimeda velasquezii	X	X	X	X	X	X	X	X	X
Microdictyon setchellianum	X	X	X	X	X				
Neomeris sp.	X	X	X	X	X	X	X	X	X
RED ALGAE									
Amphiroa sp.	X		X						
Asparagopsis taxiformis						X			
Non-geniculate calcified branched red algae	X		X	X	X	X			
Dasya irridescens				X		X	X		X
Gibsmithia hawaiiensis					X		X		
Haloplegma duperreyi			X						
Hypnea sp.		X							
Laurencia sp.							X		

Liagora spp		X					X		
Martensia sp.				X	X	X			X
Nemastoma sp.					X	X			
Peysonnellia spp.	X	X		X	X	X	X		
BROWN ALGAE									
Dictyota spp.	X								
Lobophora variegata	X	X	X		X	X	X	X	X

J.3.2. Corals

Coral REA surveys were conducted at all nine sites that were selected by Coral Reef Ecosystem Division (CRED) and partners in 2003 for long-term monitoring. Of these nine sites, all were most recently surveyed by CRED in October 2004. Permanent transect markers were installed at all nine sites this year along the first two transect lines by members of the REA fish team with the intention of reducing error because of spatial imprecision on future surveys. Global Positioning System site coordinates were taken directly at the float that marked the beginning of the first transect line, and a compass heading for the transects was recorded after descending in order to facilitate relocating the markers on future surveys.

J.3.2.1 Coral populations

A total of 1920 colonies belonging to 16 anthozoan taxa were enumerated within belt transects enclosing 450m^2 benthic substrate (Table J.3.2.1). The most frequently occurring taxa were *Porites lobata*, *Cyphastrea ocellina*, *Montipora capitata*, and *Porites evermanni*. One additional scleractinian taxon not seen within belt transects was observed within the larger survey area surrounding the transect belts (*Pocillopora eydouxi*).

Table J.3.2.1. Number of anthozoans enumerated within belt transects at Lisianski during 2006 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Taxon	# of colonies	Percent of total
Acropora cytherea	0	0.0
Acropora valida	0	0.0
Acropora humilis	0	0.0
Montipora capitata	339	**17.7**
Montipora patula	131	6.8
Montipora verilli	0	0.0
Montipora flabellata	0	0.0
Montipora turgescens	0	0.0
Montipora incrassata	0	0.0
Pavona duerdeni	41	2.1
Pavona varians	1	0.1
Pavona maldivensis	21	1.1
Cyphastrea ocellina	360	**18.8**
Leptastrea purpurea	6	0.3
Fungia scutaria	18	0.9
Pocillopora damicornis	122	6.4

Taxon	# of colonies	Percent of total
Pocillopora eydouxi	0	0.0
Pocillopora ligulata	12	0.6
Pocillopora meandrina	21	1.1
Porites brighami	11	0.6
Porites compressa	187	9.7
Porites evermanni	229	**11.9**
Porites lobata	396	**20.6**
Psammocora stellata	25	1.3
Palythoa sp.	0	0.0
Zoanthus pacifica	0	0.0
Total # colonies	1920	100.0
Area surveyed, m^2	450	

A size class distribution of all corals enumerated within belt transects is shown in Figure JG.3.2.1. Of the 1895 colonies whose maximum diameter was visually estimated, 47.5% had a maximum diameter <10 cm, and 14.4% had a maximum diameter >40 cm. At a future date, colony counts and size class distributions will be compared with data recorded during 2003–2004 surveys.

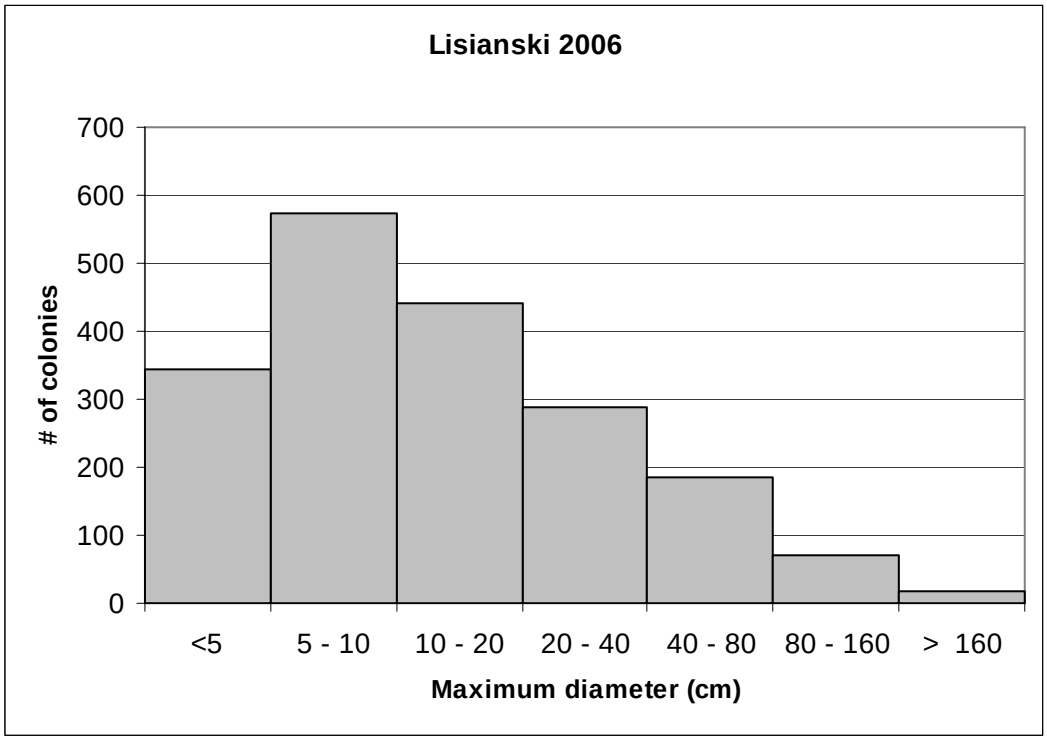

Figure J.3.2.1. Size class distribution of 1920 coral colonies enumerated within belt transects at Lisianski in 2006.

Substantial bleaching was observed at Lisianski during October 2004 surveys, particularly in *Montipora patula* (56.3% of 190 colonies tallied within belt transects),

Porites evermanni (52.6% of 154 colonies tallied within belt transects), and *Porites lobata* (23.1% of 91 colonies tallied within belt transects) (Kenyon and Brainard, in press, Atoll Research Bulletin). Though a coral disease specialist was tasked in 2006 with making specific observations of coral health and disease (see Section J.3.2.2), Kenyon's impressions in 2006 were that living colonies of these taxa were well pigmented compared to 2004.

References

Kenyon, J. C., and R. E. Brainard.
In press. Second recorded episode of mass coral bleaching in the Northwestern Hawaiian Islands. Atoll Research Bulletin 543:

J.3.2.2. Percent benthic cover

Percent benthic cover surveys at Lisianski Island were conducted in concert with the fish, coral population, and algae REA surveys, at nine different sites. The line-intercept methodology quantified a total of 918 points along 450 m of coral reef communities, including mainly bank reefs and spur-and-groove systems. Survey-transect depths ranged between 6.4 and14.8 m for all reef locales visited. The point-count surveys at Lisianski Island indicated that the mean percent live coral cover for all sites combined was relatively high; 36.7%; much higher than at the previously visited atoll/island groups. At Lisianski, coral cover in excess of 50% was encountered at Sites LIS-R7, R-10, and 10 along the southwestern sector. The bank and spur-and-groove reef systems at these locales were predominantly built and dominated by a combination of *Porites lobata, P. evermanni, and P. compressa*. Sites LIS-R14 and LIS-17 on the west and northwest regions, respectively, also exhibited moderately high (40–45%) percent live coral cover.

From the 16 or so scleratinian taxa reported for all sites combined at Lisianski (see above section on coral population dynamics by Kenyon), 9 were enumerated along the line-intercept transects (Table J.3.2.2.1), with *Porites* spp. being the most numerically abundant (86%). Below, Table J.3.2.2.1 provides a complete itemized analysis of percent cover for the different benthic elements enumerated using the line-intercept methodology at Pearl and Hermes Atoll. Additionally, Figure J.3.2.2.1 illustrates the contribution of the different scledractinain taxa to the total percent live coral cover.

Table J.3.2.2.1 Percent cover of the benthic elements at Lisianski Island using the point-intercept method during the 2006 REA activities.

Species	Total point counts	% Cover
Cyphastrea ocellina	5	0.5
Leptastrea purpurea	1	0.1
Montipora capitata	20	2.2
Montipora patula	13	1.4
Pavona duerdeni	3	0.3
Pocillopora damicornis	5	0.5
Porites compressa	55	6.0
Porites evermani/lutea	76	8.3
Porites lobata	159	17.3
Macro-algae	49	5.3
Halimeda	100	10.9
Branched calcified Rhodophyta	7	0.8
Coralline algae	23	2.5
Pavement/cca	89	9.7
Rubble/cca	3	0.3
Dead/cca	27	2.9
Pavement/turf	176	19.2
Dead/turf	73	8.0
Rubble/turf	8	0.9
Sand	26	2.8
Grand Total	918	

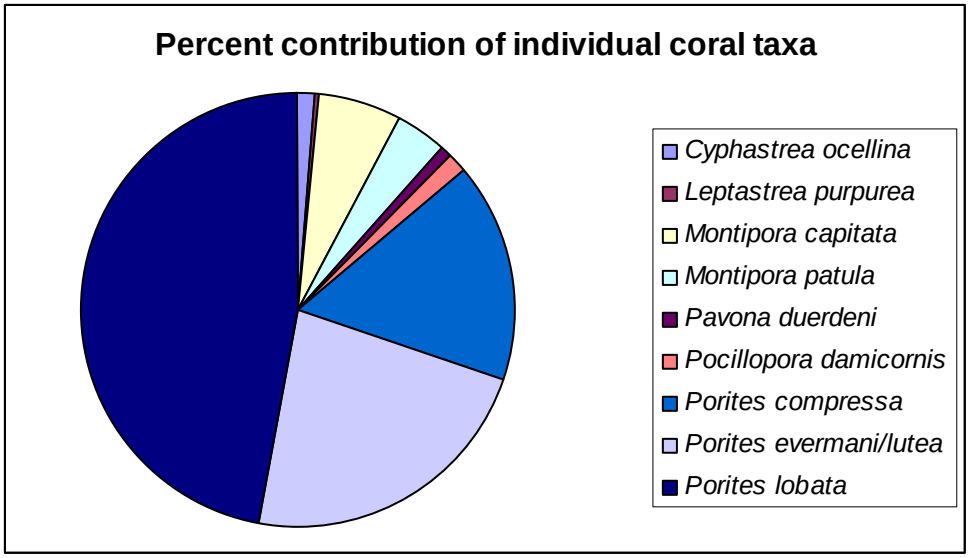

Figure J.3.2.2.1. Percent contribution of the different taxa to the total live coral cover

J.3.2.3. Coral disease

At Lisianski Island, the coral disease REA surveyed a total area of approximately 2400 m^2 at nine different sites during the RAMP cruise of 2006; this represents an average of approximately 300 m^2 at each survey site. At Sites LIS-R14 and LIS-16 only one, 150 m^2, plot was surveyed for disease because of strong currents and lack of remaining bottom time.

During 2003–2004, Kenyon reported rather widespread bleaching at Lisianski, with both *Montipora patula* and *Porites evermanni* exhibiting moderately high bleaching frequencies (56.3% and 52.6%, respectively), and with lesser bleaching incidences in *Pocillopora damicornis, Porites lobata, Pocillopora meandrina, Porites compressa,* and *Montipora capitata* (27.3%, 23.1%, 20.0%, 9.1%, and 2.4%, respectively). In 2006, bleaching was observed at all sites visited, but it was mild, focal, and affected ca. <1% of the coral population, primarily *Porites lobata*, *Porites evermanni*, and few colonies of *Montipora capitata* (see Table J. 3.2.3.1 below). The highest incidence of bleaching (20 cases within the 300 m^2 survey plot) was encountered at Site LIS-R14. The lowest incidence of bleaching was found at LIS-R12, also on the northwestern sector of the bank reef system. At the time of surveys water temperature was over 27°C and underwater visibility ca. 15 m.

Bleaching was more prevalent on colonies of *Porites lobata* than any of the other species affected (see Table J.3.2.3.1 below). The extent of bleaching and bleaching severity were scored in the field, on a scale of 1 to 5, with 1.0 being mild (pallor) and affecting 0-10% of the colony, and 5.0 being acute/severe (fully) and affecting 100% of the colony. Based on this semiquantitative scale, bleaching within individual colonies of *Porites* spp. averaged 1.6, generally affecting <10% of the colony surfaces and with tissues exhibiting focal pallor only. By contrast on *Montipora* cf. *capitata* colonies, bleaching was multifocal to diffuse and averaged 2.5; in some isolated cases, 100% of colony tissues appeared fully bleached.

Between 2003 and 2004 Dr. Greta Aeby reported five different disease states for corals at Lisianski Island, including: (1) *Porites* trematodiasis, (2) *Porites* tissue loss, (3) *Porites* dark tissue thinning, (4) Porites brown necrotizing disease, and (5) *Montipora* white syndrome. Aside from bleaching, during the 2006 NWHI Coral Reef Assessment and Monitoring Program (NOW-RAMP) cruise, we detected three other types of coral diseases affecting five scleractinian species, including: (1) tissue loss on colonies of *Porties lobata*, *P. compressa*, and *P. evermanni*; (2) *Porites* trematodiasis, and (3) growth anomalies on colonies of *Montipora patula* and *Montipora capitata*. A few cases of *Porites* tissue loss appeared similar to the poritid discolored tissue thinning syndrome described by Aeby. Tissue samples were procured to verify this finding (see below).

Bleaching was the most numerically prevalent coral affliction encountered at Lisianski; nearly four cases per 100 m^2 surveyed. These levels, however, are much lower compared to the levels reported by Kenyon for 2004 and by no means represent evidence of widespread bleaching. At a later date, based on coral cover and colony densities the prevalence levels for the above coral syndromes will be estimated.

Equally important as coral diseases, were the 31 cases of compromised health state (CHS) observed (Table J.3.2.3.1). Within this health category, two sets of gross morphologies were identified, including: (1) patchy, hyper- and hypo-pigmentation, affecting colonies of *Porites lobata* at Sites LIS-R14, -R9, and -10; and (2) multifocal, regularly shaped (0.5 cm diameter), pink discolorations (pigmentation responses) affecting colonies of *Porites lobata* and *Porites evermanni*. These pigmentation responses were quite conspicuous and different from the swollen yellowish or pink nodules that characterize *Porites* trematodiasis.

Tissue samples for histological analyses were also procured, including seven samples of tissue loss with discoloration on *Porties* spp., and two samples of Porites pink round discolorations. At a future date, histological examination of tissues will be used to confirm specific disease etiology.

Table J.3.2.3.1 Compromised health states.

Type of disease/syndrome	Species	Total
Bleaching	*Montipora cf. capitata*	20
	Porites compressa	1
	Porites evermanni	12
	Porites lobata	59
Growth anomalies	*Montipora cf. capitata*	2
	Montipora patula	1
Tissue loss	*Porites compressa*	1
	Porites evermanni	3
	Porites lobata	9
Trematodiasis	*Porites compressa*	2
	Porites evermanni	2
	Porites lobata	3
CHS		
Discoloration (over-pigmentation and pallor)	*Porites lobata*	4
Pigmentation responses (pink spots other than trematodiasis)	*Porites evermanni*	5
	Porites lobata	22
Grand Total		146

Below, Figure J.3.2.3.1 illustrates the cumulative number of cases of disease and compromised health states enumerated for all survey areas combined at Lisianski Island during the 2006 NOW-RAMP cruise. In addition, Figure J.3.2.3.2 presents an itemized breakdown of the coral taxa exhibiting disease and compromised health states. At a future

date, these data will be related to coral colony densities and coral cover in order to numerically estimate disease prevalence. These results will be contrasted with data collected during prior surveys, as well as with other sites within the Northwestern Hawaiian Islands chain.

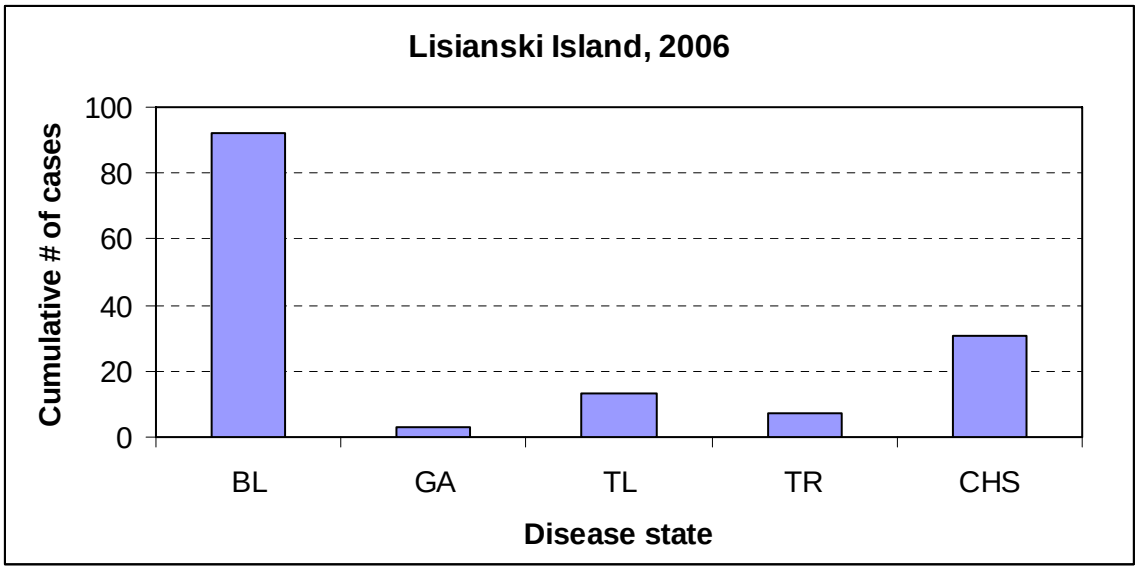

Figure J.3.2.3.1 Cumulative number of cases of disease conditions and compromised health state conditions enumerated along the survey area at Lisianski Island during the 2006 RAMP cruise. BL: bleaching; GA: growth anomaly; TL: tissue loss; TR: trematodiasis; and CHS: compromised health state, including *Porites* hyper- and hypo-pigmentation, *Porites* pink round pigmentation responses, and other fitness-imperil conditions.

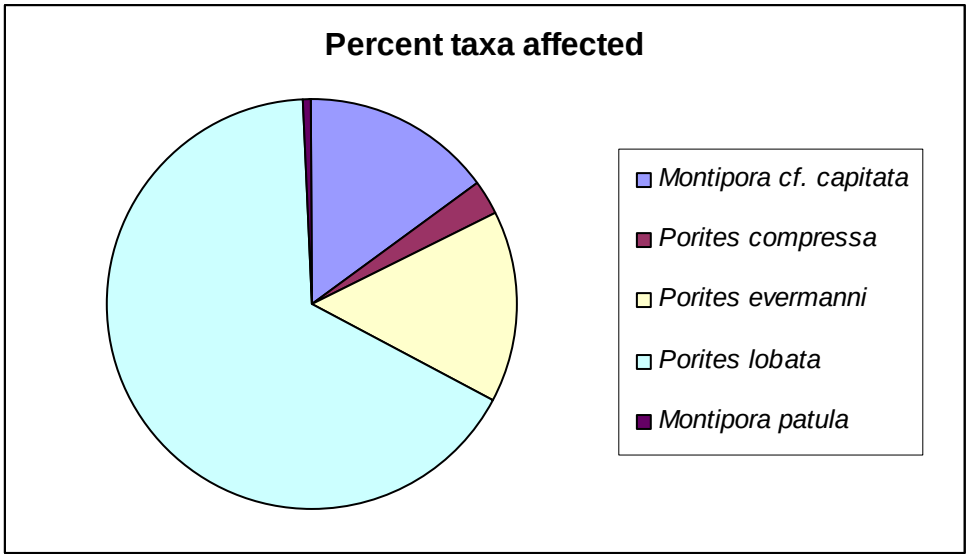

Figure J.3.2.3.2. Taxonomic breakdown of corals exhibiting disease and compromised health states at Lisianski Island, 2006.

J.3.2.4 USFWS permanent coral transects

Three permanent 50 m long transects were established in shallow water and marked with stainless steel pins near Lisianski Island in September–October 2002. Site LIS-1P was established on the southwest forereef reef crest margin at depths of 4 to 15 ft. Site LIS-6P was established near the opposite, east side of the island at similar depths along the forereef reef crest margin. The third Site LIS-9P was established off the northern forereef slope of the island at depths of 24–49 feet. Water visibility, wave action, and currents are notably stronger at the latter two sites (LIS-6P, -9P) located windward of the island. The first site (LIS-1P) is downdrift of the island and in the direct path of current and water flow from the island.

In 2002 coral coverage was estimated at 4.8%, coral frequency at 3.8 corals per m^2, and mean diameter at 14.5 cm at the southwest site of LIS-1P. Corals there were primarily plates of *Montipora* corals intermixed with green algal growths of *Neomeris* and *Microdictyon.* On the opposite side, at the east site of LIS-6P, large plates of the same coral *Montipora* cf. *turgescens* dominated the bottom, averaging 45.8% coral cover, 1.8 corals per m^2, and with an average diameter of 57 cm in 2002. The northern offshore site consisted of hard bottom covered with encrusting *Montipora corals* at shallow (20-25 ft) depths and transitioned to larger, widely spaced colonies of *Porites* lobe corals and *Pocillopora* rose corals over a rubble sand bottom at depths of 30–50ft. There, coral coverage was 15.5%, mean diameter 23 cm, and frequency of 5.06 corals per m^2 in 2002.

Four years later, resurveys yielded a near total collapse of corals at Site LIS-1P. Coral cover was estimated at <1%, mean diameter at 4.56 cm, and coral frequency at 0.36 corals per m^2, translating to only 17 corals for the entire transect. In great contrast, the two windward sites fared much better over the 4 years with preliminary estimates of coral cover higher in 2006. Mean diameter at Site LIS-6P was less but still substantial at 40.6 cm. Likewise Site LIS-9P showed smaller mean diameter for corals at 16.3 cm, but coral frequencies nearly doubled at both windward sites, with 2006 values at 4.00 and 9.84 corals per m^2, respectively. The small brain coral *Cyphastrea* appeared at all three sites for the first time in 2006, and *Pocillopora* increased in size and numbers at all three sites. The plate coral *Montipora* nearly disappeared by 2006 at Site LIS-1P with only 10 small colonies remaining from 184 mostly larger colonies in 2002. At the other two sites *Montipora* plate coral increased dramatically for smaller to middle-sized corals. The lobe coral *Porites* also declined at the southwest site of LIS-1P, but increasing modestly at the north site of LIS-9P. Figures J.3.2.4.1 through J.3.2.4.3 show the changes in size distribution for all corals over the 4-year period at the three sites.

The collapse of the coral community at the southwest site of LIS-1P may have been caused by warm water leading to a coral bleaching event followed by the overgrowth of algae, the latter perhaps stimulated by plentiful nutrients leaching from the island and derived by extensive guano production generated by the large resident seabird populations at Lisianski Island. Water temperature felt warmer and has a longer residence time in shallow depths where solar heating would be higher. Also the waters to the southwest were noticeably greener from higher phytoplankton productivity. In contrast, water clarity was

better, water motion stronger, and temperatures cooler at the two windward sites that showed increased coral development over the 4-year period. It will be important to continue monitoring the three sites to determine if and when coral recovery occurs at Site LIS-1P and whether coral increases are sustained at the other two sites (LIS-6P, -9P).

Figures J.3.2.4.1 through J.3.2.4.3. Size distribution of all corals at the three permanent transects at Lisianski Island in 2002 and 2006. (after Maragos, unpubl.).

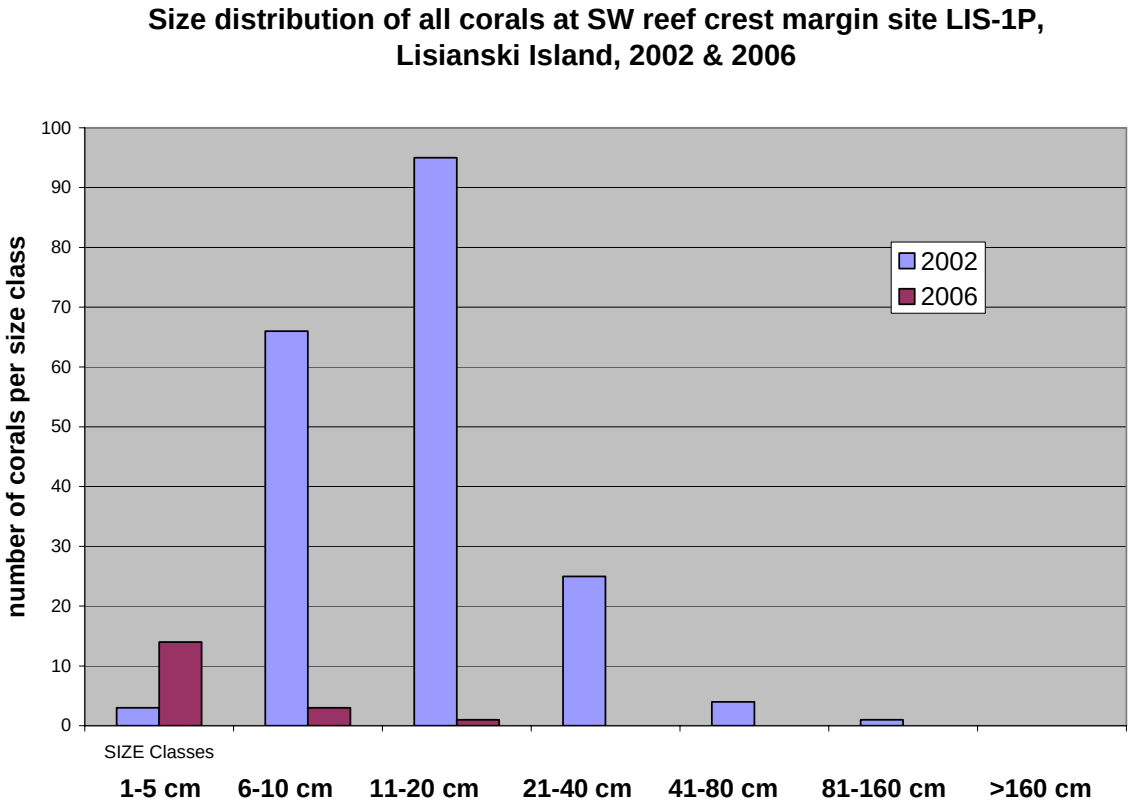

Figure J.3.2.4.1. Size distribution of all corals at Lisianski Site LIS-1P.

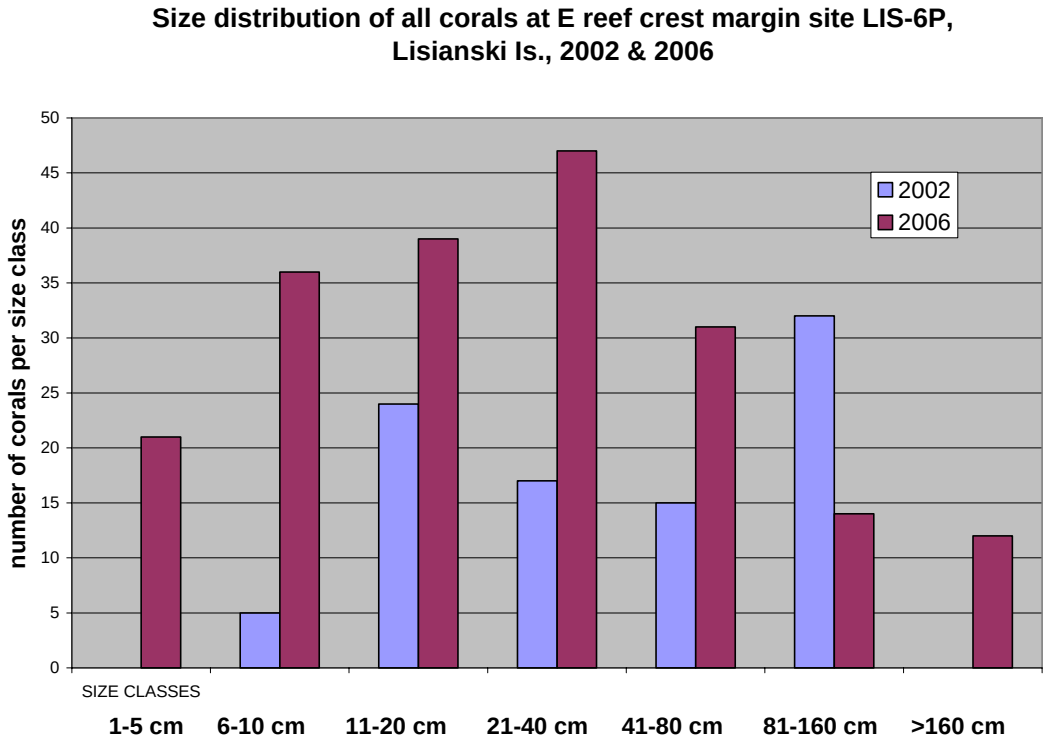

Figure J.3.2.4.2. Size distribution of all corals at Lisianski Site LIS-6P.

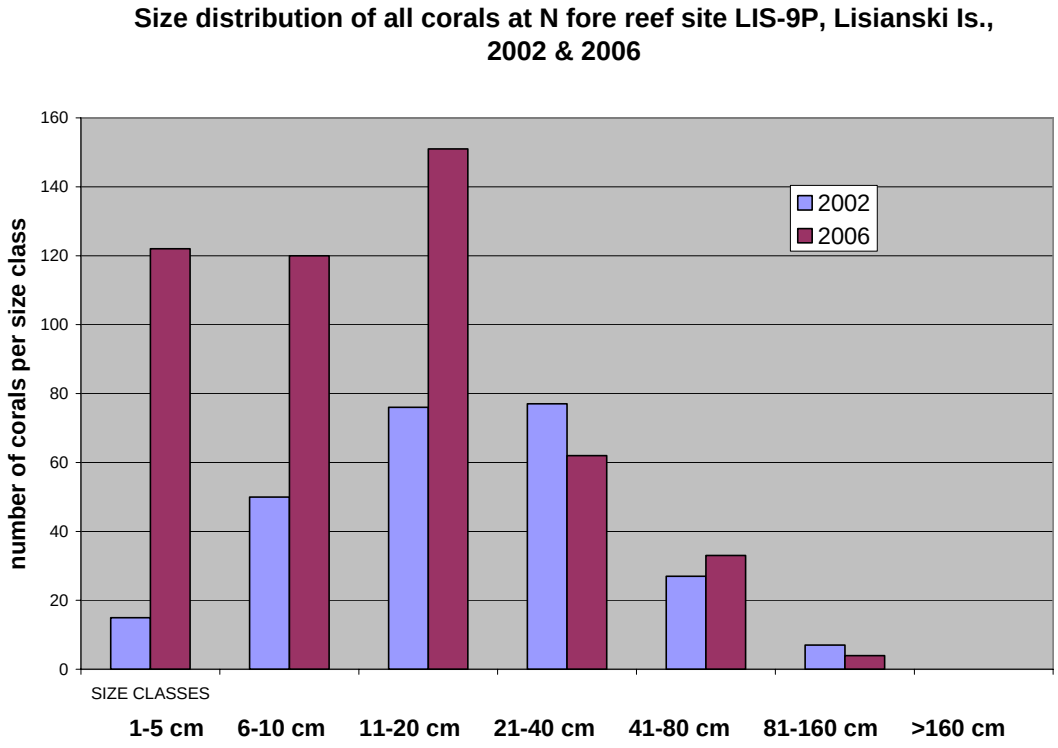

Figure J.3.2.4.3. Size distribution of all corals at Lisianski Site LIS-9P.

J.3.3 Towed-diver Benthic Surveys

The 13 towed-diver surveys covering 30.47 kilometers of habitat at Lisianski and Neva Shoals were classified into three general areas: forereef (4), backreef (2), and bank (6). Forereef tows (Fig. J.5.2., tows 1, 2, 4, 5) were completed along the sections of reef that were within 3–3.5 nautical miles of Lisianski Island. Backreef tows (Fig. J.5.2., tows 3 & 12) were conducted in the immediate vicinity of the island, inland of the eastern and northern breakwater reef environment. Bank/shoal towed-diver surveys (Fig. J.5.2, tows 6-11) ranged from 4 to 8.5 miles away from the island and were associated with the area known as Neva Shoals.

The four forereef towed-diver surveys consisted of a variety of habitats, ranging from a single low-relief sand flat to highly complex coral patch reefs and continuous reef systems. The average hard coral cover was 25.9%, while average macroalgae and coralline algae cover was recorded at 28% and 27.8%, respectively. The highest coral cover was logged during the easternmost forereef survey (Fig. J.5.2., tow 2; 45.5%) while the lowest was recorded in the southwest (Fig. J.5.2., tow 5; 9.5%). Finally, *Halimeda* were noted as the predominant algae in all recorded forereef surveys, ranging between 21% and 33% total forereef bottom cover.

The overall complexity of the two backreef surveys ranged from low to medium-high, with terrain consisting of shallow coral pavement reef (windward/eastern survey) and patch reefs in sand flats (leeward/western survey). The average hard coral cover was 19.9% and composed of predominantly *Montipora* species, while the average macroalgae and coralline algae cover was recorded at 47.3% and 2.2%, respectively. An interesting note was that the hard coral cover on the windward shore was much higher (33%) than the leeward shore (6.7%). Macroalgae cover was similar during both backreef tows (44.3% windward survey; 50.6% leeward survey) and was dominated by *Halimeda* species, along with *Nemomeris annulata* and *Asparagopsis taxiformis*.

Of the six bank towed-diver surveys conducted along Neva Shoals, overall bottom complexity ranged from low to high and consisted of a variety of terrain which included *Halimeda* and coral sand flats, patch reefs, and continuous reef. Average/overall hard coral cover was recorded as 38.7%, while the overall macroalgae and coralline algae cover was recorded as 17.2% and 22.8%, respectively.

A number of interesting benthic observations were noted during the bank surveys. Average hard coral cover increased as the team completed towboard surveys from the east towards the southern section of Neva Shoals (patch reefs → continuous reef), and decreased dramatically as surveys continued from the south towards the northwest where water turbidity was significantly higher (much poorer visibility) and the area covered by sand flats increased (continuous reef→ patch reef → sand flats). The highest average hard coral cover recorded during any survey was recorded at 72.5% along the southeastern survey of Neva Shoals (Fig. J.5.2., tow 8). The majority of observable hard coral species was dominated by *Porites* and/or *Montipora* species in all bank surveys. Also, large *Fungia* clusters were noted in some areas (e.g., Fig. J.5.2., tow 8; 9/10 time segments).An area of *Acropora* cover was

also observed during the southeastern towed-diver survey (Fig. J.5.2., tow 8), which constitutes a new record and range extension for the Northwestern Hawaiian Islands. Further investigation by Dr. Jim Maragos revealed that the colonies observed by towboard divers belonged to *Acropora valida*, with 1-2 additional species of *Acropora* that will require further/future analysis for identification.

The predominant macroalgae cover for bank towboard surveys remained *Halimeda*, which was recorded in almost every time segment during bank towed-diver surveys. *Microdictyon setchellianum* was also prevalent along the small patch reefs found within the sand flats in the southwest (Fig. J.5.2., tow 10). Finally, the green algae *Caulerpa taxifolia* (identified by Dr. Peter Vroom) was found in small patches along the eastern shoal sand flats (Fig. J.5.2., tow 6).

There was an overall lack of invertebrate populations noted during all combined towed-diver surveys around Lisianski and Neva Shoals. The highest number of sea urchins was recorded in the northwestern forereef survey, with an average of 101 urchins/time segment (Fig. J.5.2, tow 5; 4/10 time segments recorded at 175 urchins). No sea urchins were recorded during the backreef surveys, and the bank surveys recorded only sporadic urchin populations. A survey in the southeast section of the bank recorded an average of 34 urchins per time segment (Fig. J.5.2, tow 7); however, the remaining surveys along the banks were largely devoid of sea urchins. It is also interesting to note that no more than two sea cucumbers and no crown-of-thorns starfish were recorded during any surveys of Lisianski and Neva Shoals.

J.4 Fish

J.4.1 REA Fish Surveys

SPC data

A total of 145 fishes of 17 species were seen in SPC surveys at the 9 Lisianski sites (16 fishes/dive), and 115 of the fishes (79%) were 50 cm or smaller. The most numerous fishes counted in SPCs were *Chlorurus perspicillatus* (29), *Caranx ignobilis* (25), and *Naso unicornis* (20). Other somewhat abundant species counted were *Aprion virescens* (11), *Bodianus bilunulatus* (10), and *Acanthurus olivaceus* (9).

BLT data

A total of 2265 fish were counted at the 9 sites on BLT transects. This reflects a fish density of 0.42 fishes/m^2. By far, the most numerically abundant species was *Thalassoma duperrey* (503 individuals counted). After the saddleback wrasse, several herbivorous species were found in high abundance: *Stegastes fasciolatus* (279 individuals counted), *Ctenochaetus strigosus* (138), *Acanthurus nigroris* (124), *Acanthurus olivaceusi* (120), *Scarus psitticus* (94), and *Chlorurus sordidus* (85). The size frequencies of all fishes counted are presented in Figure J.4.1.1.

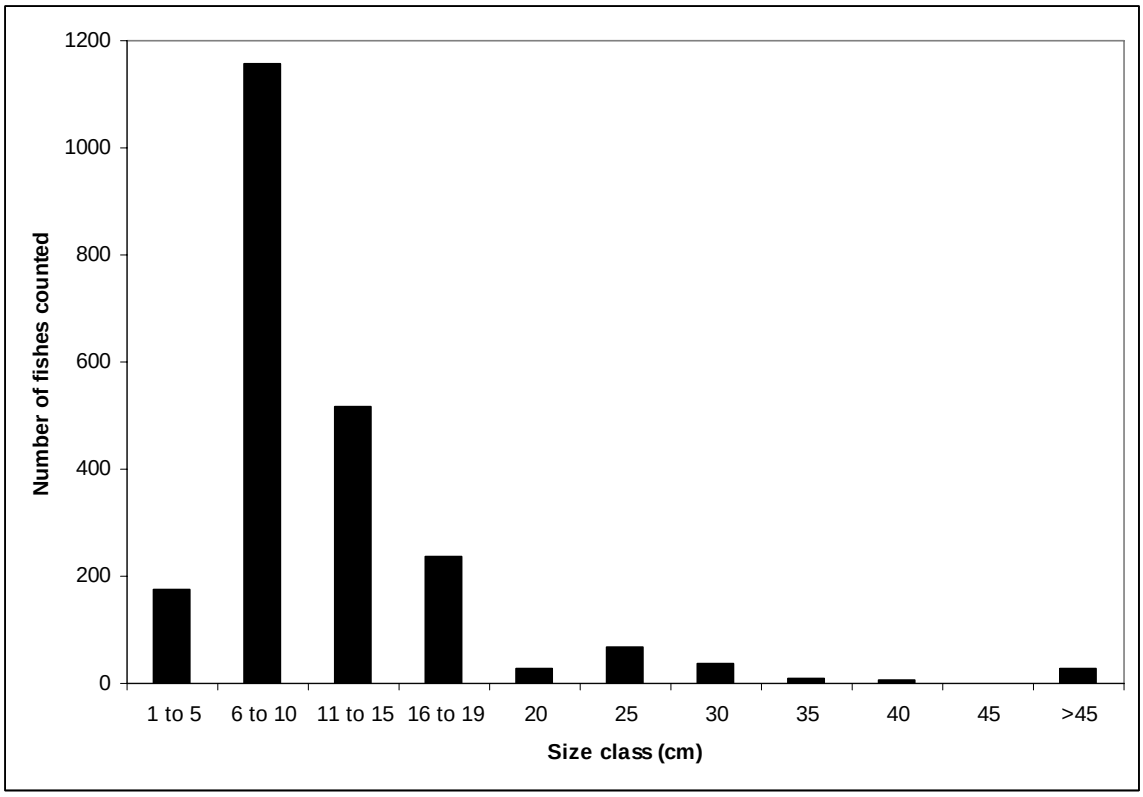

Figure J.4.1.1. Size frequencies of fish at Lisianski Island.

Overall observations:

The size frequency of fishes counted on belt transects at Lisianski was clearly skewed toward small individuals in the 6–10 cm range. Ninety-four species of fishes were recorded at Lisianski overall. As we surveyed Lisianski subsequent to the northern sites, we noted the reappearance of several southern species that we had not seen in a while, such as *Scarus rubroviolaceus, Naso lituratus, Monotaxis grandoculis,* and *Acanthurus olivaceus.*

We noted that the large predators at our dive sites around Lisianski seemed more aggressive/less wary of divers than they were elsewhere. *Caranx ignobilis* at Sites 16–18 were particularly aggressive, often taking bites at our reels, clipboards, or epoxy gun. The Galapagos sharks and *Aprion virescens* were also coming nearer to divers than elsewhere, affording us better photographic opportunities (notwithstanding the generally murky conditions).

J.4.2 Towed-diver Fish Surveys

Table J.4.2.1. HI06_11 Towed-Diver Survey Report for Lisianski Island and Neva Shoals.

			Survey Length				Mean Depth
		N	Min	Max	Median	Sum	Median
Lisianski Island And Neva Shoals	**09/25/2006**	5	1.48	3.25	2.46	12.13	-11.04
	09/26/2006	5	2.56	2.95	2.65	13.62	-12.75
	09/27/2006	2	2.27	2.44	2.36	4.72	-5.82
	All	12	1.48	3.25	2.59	30.47	-10.69

N = number of surveys conducted.

Survey Length is given in kilometers.

Depth readings are taken at 5 sec intervals during each 50 min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of eight species of large fishes (>50 cm TL) representing five families were observed at Lisianski Island and Neva Shoals during the survey period (09/25/06–09/27/06). The mean number of fishes (all species pooled) observed by divers was 0.044 ha^{-1}, and the seven mostly commonly recorded species are shown in Figure J.4.2.1. The bluefin trevally (*Caranx melampygus*) was the most abundant species observed during the quantitative surveys with a mean number of 0.80 fishes observed per hectare. The giant trevally (*Caranx ignobilis*) was the second most abundant fish species encountered during the survey period with a mean numeric density of 0.39 ha^{-1}.

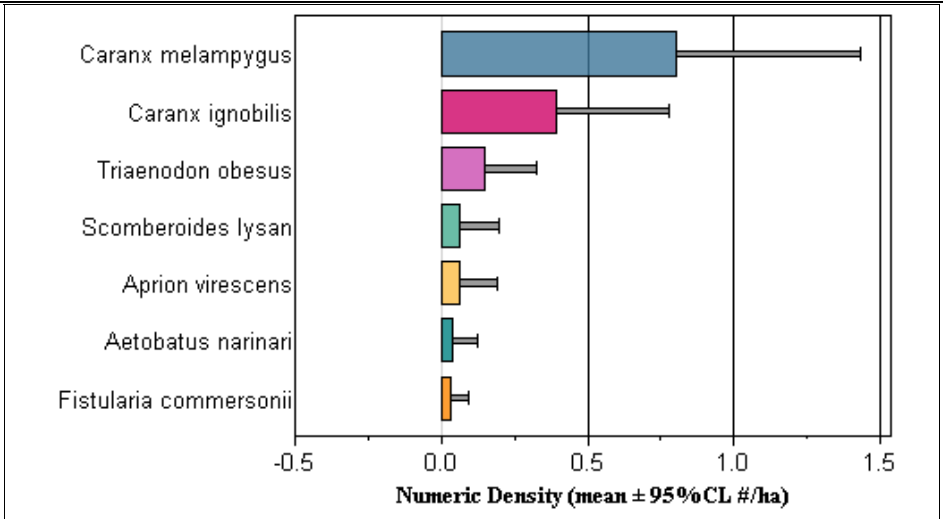

Figure J.4.2.1. The mean numeric density (number of fishes ha^{-1}) of the twenty-two most commonly observed fishes at Lisianski Island and Neva Shoals during the survey period.

The grand mean biomass density of fishes observed on the shallow reefs (<30 m) at Lisianski Island and Neva Shoals during the survey period was 3.92×10^{-4} t ha^{-1}. The giant trevally (*Caranx ignobilis*) and whitetip reef shark (*Triaenodon obesus*) accounted for more than 75% of the total mean biomass of large fishes (Fig. J.4.2.2). The giant trevally alone accounted for half of the total large fish (>50 cm TL) biomass with a mean biomass density of 6.46×10^{-3} t ha^{-1}. The whitetip reef shark followed behind with a mean biomass density value of 3.62×10^{-3} t ha^{-1}.

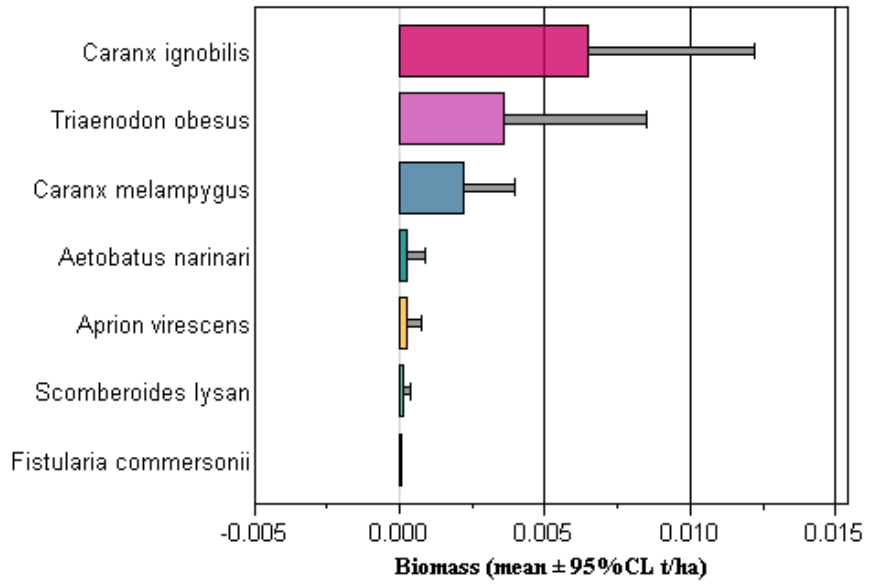

Figure J.4.2.2. The mean biomass (t ha^{-1}) of the twenty-two most commonly observed fishes larger than 50 cm (TL) at Lisianski Island and Neva Shoals during the survey period.

J.4.3 Shark receivers

We deployed two new underwater receivers on sand screws at this location, one on the east side of Lisianski Island and the other at the southern end of Neva Shoals (Table A.5.2).

J.5 Maps

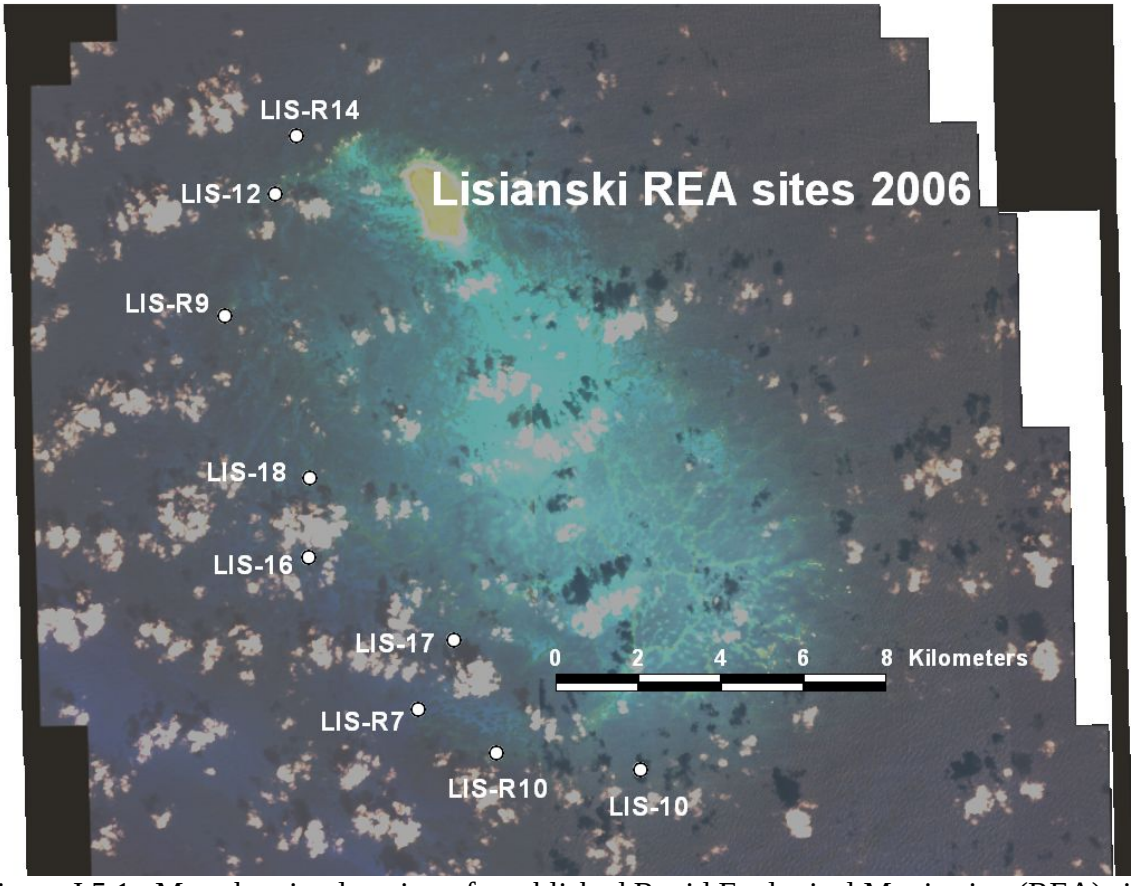

Figure J.5.1. Map showing location of established Rapid Ecological Monitoring (REA) sites at Lisianski Island/Neva Shoals.

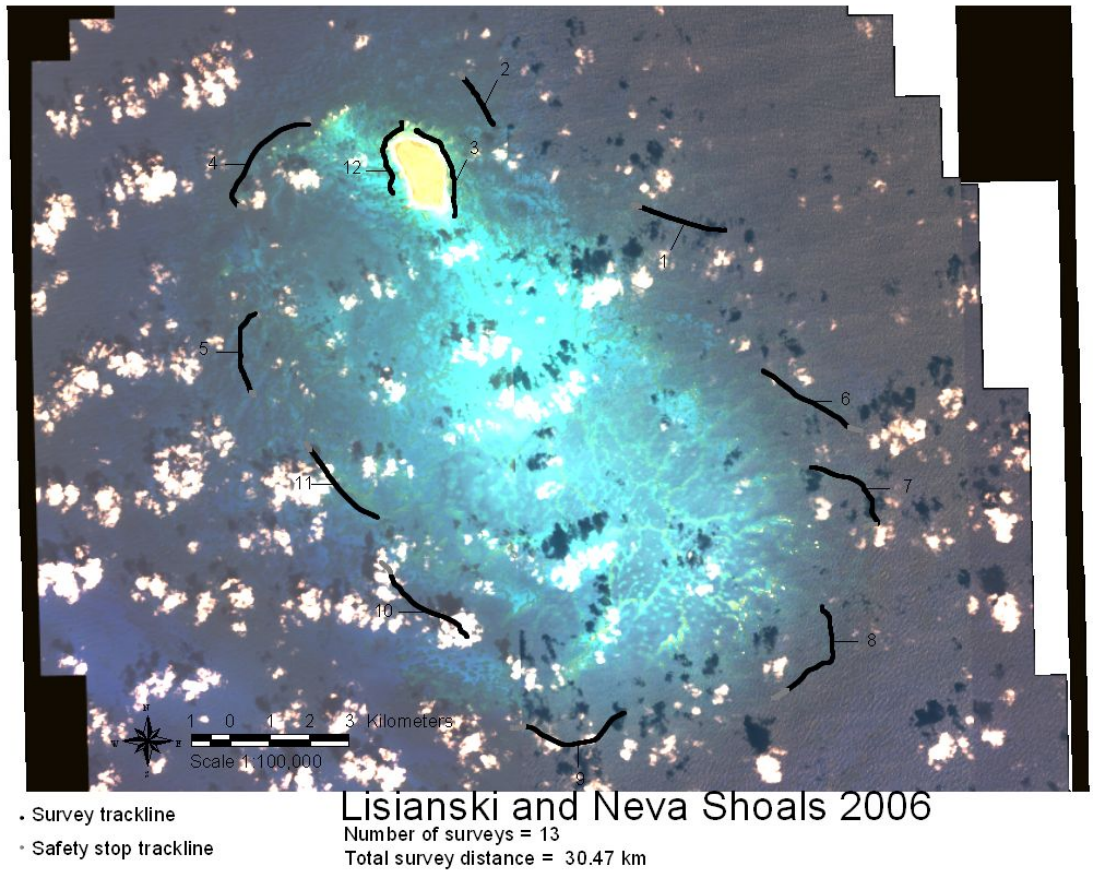

Figure J.5.2. Map showing location of towboard tracks at Lisianski Island/Neva Shoals.

Appendix K: Summary Tables

K.1. Rapid ecological assessment (REA) Site Location and Permanent Transect Information

Table K.1. REA sites visited during 2006 NWHI Coral Reef Assessment and Monitoring Program. Global positioning system positions indicate the beginning of permanent transects (when applicable).

Northwestern Hawaiian Islands RAMP REA sites, HI06-11, September/October 2006
Prepared by Jean Kenyon; 64 REA sites
Not among the sites selected by CRED and partners in 2003 for long-term monitoring, but used as alternative REA sites due to prevailing sea conditions

		Latitude			Longitude			
Site #	Date surveyed	degrees	minutes	N/S	degrees	minutes	E/W	General location
Necker (2 sites)								
NEC-2	9/3/06	23	34.432	N	164	42.263	W	NW
NEC-4	9/3/06	23	34.711	N	164	42.378	W	SW
French Frigate Shoals (10 sites)								
FFS-30	9/4/06	23	50.986	N	166	17.868	W	NW lagoon
FFS-21	9/4/06	23	50.809	N	166	19.612	W	NW lagoon
FFS-H6	9/4/06	23	52.806	N	166	16.384	W	North forereef
FFS-12	9/5/06	23	38.301	N	166	10.803	W	S lagoon
FFS-34	9/5/06	23	37.675	N	166	8.123	W	S forereef
FFS-R29	9/5/06	23	40.697	N	166	8.799	W	SE patch reef
FFS-R46	9/30/06	23	46.157	N	166	15.704	W	La Perouse Pinnacles
FFS-32	9/30/06	23	48.366	N	166	13.838	W	north central lagoon
FFS-33	9/30/06	23	50.188	N	166	16.010	W	north lagoon
FFS-35	10/1/06	23	47.437	N	166	13.921	W	central lagoon
Maro Reef (9 sites)								
MAR-R12	9/7/06	25	28.267	N	170	38.576	W	North spur
MAR-R1	9/7/06	25	27.678	N	170	40.524	W	S of NW spur
MAR-R3	9/7/06	25	25.131	N	170	40.167	W	WNW spur
MAR-22	9/8/06	25	22.726	N	170	34.042	W	S end western spur
MAR-6	9/8/06	25	23.898	N	170	34.439	W	mid section western spur
MAR-8	9/8/06	25	24.996	N	170	35.025	W	northerly end western spur
MAR-R5	9/9/06	25	22.102	N	170	30.077	W	SE spur
MAR-31	9/9/06	25	20.642	N	170	31.700	W	S end of south spur
MAR-32	9/9/06	25	21.245	N	170	32.358	W	mid section south spur
Laysan (3 sites)								
LAY-5	9/10/06	25	47.244	N	171	43.743	W	N side
LAY-R12	9/10/06	25	46.662	N	171	44.833	W	NW side
LAY-R9	9/10/06	25	45.238	N	171	44.463	W	SW side
Pearl and Hermes (13 sites)								
PHR-R32	9/12/06	27	50.072	N	175	45.210	W	E backreef
PHR-R31	9/12/06	27	49.586	N	175	47.484	W	SE lagoon patch reef
PHR-R26	9/12/06	27	47.143	N	175	46.825	W	SE forereef
PHR-R42	9/13/06	27	45.188	N	175	56.926	W	SSW forereef
PHR-31	9/13/06	27	46.532	N	175	58.401	W	SW backreef

PHR-30	9/13/06	27	46.722	N	175	53.705	W	S backreef
PHR-33	9/14/06	27	47.128	N	175	49.425	W	S forereef
PHR-32	9/14/06	27	46.346	N	175	56.376	W	SW lagoon patch reef
PHR-22	9/14/06	27	47.715	N	175	51.997	W	S backreef
PHR-34	9/22/06	27	45.353	N	175	57.707	W	SSW forereef
PHR-R39	9/23/06	27	56.446	N	175	51.705	W	NW forereef
PHR-R44	9/23/06	27	54.627	N	175	54.276	W	WNW forereef
PHR-24	9/23/06	27	55.180	N	175	51.688	W	NW patch reef
Midway (9 sites)							W	
MID-2	9/15/06	28	11.840	N	177	20.746	W	S forereef
MID-R7	9/15/06	28	11.782	N	177	22.501	W	S forereef
MID-R3	9/15/06	28	11.415	N	177	23.993	W	SSW forereef
MID-3	9/16/06	28	13.074	N	177	20.644	W	SE lagoon patch reef
MID-R20	9/16/06	28	13.890	N	177	19.091	W	E backreef
MID-R25	9/16/06	28	11.620	N	177	24.109	W	SW backreef
MID-1	9/21/06	28	16.148	N	177	23.181	W	NW backreef
MID-H21	9/21/06	28	16.660	N	177	21.973	W	N backreef
MID-H11	9/21/06	28	13.060	N	177	24.193	W	SW patch reef
Kure (9 sites)								
KUR-12	9/17/06	28	22.940	N	178	19.474	W	S forereef
KUR-2	9/17/06	28	27.218	N	178	20.641	W	NW forereef
KUR-14	9/17/06	28	27.209	N	178	19.716	W	N backreef
KUR-R33	9/18/06	28	25.013	N	178	22.709	W	W forereef
KUR-R36	9/18/06	28	25.221	N	178	22.285	W	W backreef
KUR-17	9/18/06	28	25.913	N	178	22.004	W	W backreef
KUR-18	9/19/06	28	25.120	N	178	20.675	W	central patch reef
KUR-9	9/19/06	28	24.352	N	178	20.536	W	S central patch reef
KUR-R35	9/19/06	28	23.588	N	178	20.960	W	SW patch reef
Lisianski (9 sites)								
LIS-R14	9/25/06	26	4.702	N	173	59.821	W	NW
LIS-12	9/25/06	26	3.954	N	174	0.102	W	NW
LIS-R9	9/25/06	26	2.360	N	174	0.747	W	WNW
LIS-18	9/26/06	26	0.257	N	173	59.642	W	W
LIS-16	9/26/06	25	59.218	N	173	59.659	W	W
LIS-17	9/26/06	25	58.141	N	173	57.766	W	WSW
LIS-R7	9/27/06	25	57.237	N	173	58.228	W	SW
LIS-R10	9/27/06	25	56.671	N	173	57.210	W	SSW
LIS-10	9/27/06	25	56.460	N	173	55.344	W	SSE

	Reef	Site		Latitude			Longitude		# of New Pins	Transect A Bearing, °	Transect B Bearing, °	Transect C Bearing, °	Notes
													54' at A, A starts at huge hole in the reef pavement. B goes across the spur and groove - 3 spurs, 2 grooves.
9/3/06	NEC	NEC-2	23	34.432	N	164	42.263	W	12	190	190	190	37' at C
9/3/06	NEC	NEC-4	23	34.711	N	164	42.378	W	12	120		120	30' depth
9/4/06	FFS	FFS-21	23	50.809	N	166	19.612	W	0*	290	310		
9/4/06	FFS	FFS-H6	23	52.806	N	166	16.384	W	12	0	0	0	on top of spur in spur-n-groove habitat,
9/4/06	FFS	FFS-30	23	50.986	N	166	17.868	W	12	320	0	270	20' depth along edge of reef spur, may be hard to spot
9/5/06	FFS	FFS-12	23	38.301	N	166	10.803	W	0*	90	90	90	Good vis, easily spotted starts at 32'
9/5/06	FFS	FFS-34	23	37.675	N	166	8.123	W	12	40	40	40	Started on top of small rock and ended on large rock
9/5/06	FFS	FFS-R29	23	40.697	N	166	8.799	W	12	120	70 changes to 45 at 15m mark		Starts at 35', bottom of reef slope - transect B ends at big yellow lobata in 15' of water
9/7/06	MAR	MAR-R12	25	28.267	N	170	38.576	W	0*	0	0	300	45 foot depth, pins down in gully next to sand on edge of dropoff.
9/7/06	MAR	MAR-R1	25	27.678	N	170	40.524	W	0	90	90	90	22 foot depth, did not place pins as didn't have permit for this new site
9/7/06	MAR	MAR-R3	25	25.131	N	170	40.167	W	12	80	60	60	60' depth comes gradually up to 45'
9/8/06	MAR	MAR-22	25	22.726	N	170	34.042	W	3**	0	0	0	46' whole thing, to find B: from end of Trans A, go 30 degrees for 7-10m to reach start of B
9/8/06	MAR	MAR-6	25	23.898	N	170	34.439	W	12	20	20	270	27' at start, ended on top of big rock in 40' - just past rock is end of reef - sand flat in 50' of water
9/8/06	MAR	MAR-8	25	24.996	N	170	35.025	W	1**	120	120	240	15' at start, Transect B goes around large pinnacle, ends in 25' of water
9/9/06	MAR	MAR-R5	25	22.102	N	170	30.077	W	12	140	100	90	Transect A starts in 24' on top of big rock, ends of dropoff into rubble. T
9/9/06	MAR	MAR-31	25	20.642	N	170	31.700	W	0	300	300	300	Transect A starts at 43' and followed depth contour; did not place pins as didn't have permit for this new site
9/9/06	MAR	MAR-32	25	21.245	N	170	32.358	W	0	270	270	300	Transect A starts at 43', followed depth contour, ended up at 45; did not place pins as didn't have permit for this new site

	Reef	Site		Latitude			Longitude		# of New Pins	Transect A Bearing, °	Transect B Bearing, °	Transect C Bearing, °	Notes
9/10/06	LAY	LAY-5	25	47.244	N	171	43.743	W	12	210	210	210	Transect A starts on flat part of reef at 27' by a dragon's head, Transect B starts at 27' goes over arch
9/10/06	LAY	LAY-R12	25	46.662	N	171	44.833	W	12	80	80	0	Transect A starts at 30 ends at 40, B starts at 40 ends up at 17'
9/10/06	LAY	LAY-R9	25	45.238	N	171	44.463	W	12	0	0	0	Transect A starts at 34', all three transects follow contour at 34-35'
9/12/06	PHR	PHR-R32	27	50.072	N	175	45.210	W	0*	220	220	270	3' depth, outside of big sand patch, almost to surf zone
9/12/06	PHR	PHR-R31	27	49.586	N	175	47.484	W	12	0	0	0	Transect A 37, Transect B 42', Transect C 41' all following contour of compressa field.
9/12/06	PHR	PHR-R26	27	47.143	N	175	46.825	W	12	60	60	60	Transect A started at 40'
9/13/06	PHR	PHR-R42	27	45.188	N	175	56.926	W	12	340	340	340	Transect A started at 45', no particular identifying features but the water was clear
9/13/06	PHR	PHR-31	27	46.532	N	175	58.401	W	0*	240	240	210	Transects were all in 20' of water adjacent to a silt channel
9/13/06	PHR	PHR-30	27	46.722	N	175	53.705	W	12	130	130	130	All Transects in 6-9' of water
9/14/06	PHR	PHR-33	27	47.128	N	175	49.425	W	12	320	350	340	Transect A starts in 37' of water, upslope from two big fish-filled holes in the reef.
9/14/06	PHR	PHR-32	27	46.346	N	175	56.376	W	1**	60	30	330	Transect A starts in 15' of water and ended in 19', follows contour adjacent to silt channel
9/14/06	PHR	PHR-22	27	47.715	N	175	51.997	W	12	200	160	160	All Transects in 3-5' of water. Don't dump divers on top of transect or they will likely be impaled!
9/15/06	MID	MID-2	28	11.840	N	177	20.746	W	12	70	60	70	All transects in 40' of water. Lots of sand at this site so not much epoxy used
9/15/06	MID	MID-R7	28	11.782	N	177	22.501	W	12	60	60	60	45' at start of Transect A, fairly constant, 42' at Transect C. Large cable at end of Transect C.
9/15/06	MID	MID-R3	28	11.415	N	177	23.993	W	12	60	70	60	45' at start of Transect A, A ended on a big rock. Terrain heterogeneous so pins not all constant depth.
9/16/06	MID	MID-3	28	13.074	N	177	20.644	W	0*	NR	NR	NR	

	Reef	Site		Latitude			Longitude		# of New Pins	Transect A Bearing, ˚	Transect B Bearing, ˚	Transect C Bearing, ˚	Notes
9/16/06	MID	MID-R20	28	13.890	N	177	19.091	W	0*	NR	NR	NR	
9/16/06	MID	MID-R25	28	11.620	N	177	24.109	W	0*	NR	NR	NR	
9/17/06	KUR	KUR-12	28	22.940	N	178	19.474	W	12	210	210	210	35' at start of Transect A, ended at 37', ran along top of spur
9/17/06	KUR	KUR-2	28	27.218	N	178	20.641	W	12	330	330	310	35' at start of Transect A, ran along top of spur
9/17/06	KUR	KUR-14	28	27.209	N	178	19.716	W	2**	NR	NR	NR	5' throughout, no bearings taken. 2 new pins installed, 4 pins replaced/refurbished
9/18/06	KUR	KUR-R33	28	25.013	N	178	22.709	W	12	120	120	120	Transect A started at 44'
9/18/06	KUR	KUR-R36	28	25.221	N	178	22.285	W	12	190	190	NR	Transect A started in 8' of water
9/18/06	KUR	KUR-17	28	25.913	N	178	22.004	W	0*	NR	NR	NR	
9/19/06	KUR	KUR-18	28	25.120	N	178	20.675	W	12	180	180	90	Transect runs through compressa about 10' above the silt line. No epoxy was used in compressa bed.
9/19/06	KUR	KUR-9	28	24.352	N	178	20.536	W	12	270	270	270	Transect A starts in 14', B at 12', C at 18'
9/19/06	KUR	KUR-R35	28	23.588	N	178	20.960	W	12	240	240	240	Transect A starts in 15' of water
9/21/06	MID	MID-1	28	16.148	N	177	23.181	W	0*	300	300	NR	Transect A starts in 5' of water, Transect B in 4'
9/21/06	MID	MID-H21	28	16.660	N	177	21.973	W	12	120	120	NR	Transects all in 3-5' of water
9/21/06	MID	MID-H11	28	13.060	N	177	24.193	W	12	120	120	120	Transects were in 13' or less of water, going straight across the top of the patch reef.
9/22/06	PHR	PHR-34	27	45.353	N	175	57.707	W	0	300	300	300	Transects were laid across the spur and groove, started at 40' on top of spur, over one groove and onto next spur. Transect B started at 43', went from top of spur over two grooves and ended on top of spur in 43'. C spanned a single gravelly groove; did not place pins as didn't have permit for this new site

	Reef	Site		Latitude			Longitude		# of New Pins	Transect A Bearing, ˚	Transect B Bearing, ˚	Transect C Bearing, ˚	Notes
9/23/06	PHR	PHR-R39	27	56.446	N	175	51.705	W	12	120	120	120	Transect A started in 40' of water, so did B, and C started in 35' of water
9/23/06	PHR	PHR-R44	27	54.627	N	175	54.276	W	0*	330	330	330	Transect A started in 41', got deeper gradually over B and C to 51'
9/23/06	PHR	PHR-24	27	55.180	N	175	51.688	W	12	300	220	150	Transects followed the 20' contour of the reef, curved around the edge.
9/25/06	LIS	LIS-R14	26	4.702	N	173	59.821	W	12	180	180	180	Transects followed the 45' contour
9/25/06	LIS	LIS-12	26	3.954	N	174	0.102	W	12	150	60	120	Transects were in approx 25' of water, A started on a big lobata head
9/25/06	LIS	LIS-R9	26	2.360	N	174	0.747	W	12	0	0	0	Transects 27', B went down to 42 across a groove
9/26/06	LIS	LIS-18	26	0.257	N	173	59.642	W	12	240	240	240	Transect A started in 22', ranged to 24' all the way through
9/26/06	LIS	LIS-16	25	59.218	N	173	59.659	W	12	300	10	60	Transects ranged from 30-40' throughout
9/26/06	LIS	LIS-17	25	58.141	N	173	57.766	W	12	20			30-31' throughout
9/27/06	LIS	LIS-R7	25	57.237	N	173	58.228	W	12	260	300	290	All Transects fall between 35 and 45
9/27/06	LIS	LIS-R10	25	56.671	N	173	57.210	W	12	90	90	120	Started on very large coral head, followed the 40' contour
9/27/06	LIS	LIS-10	25	56.460	N	173	55.344	W	12	60	60	60	Followed the 30' contour
9/30/06	FFS	FFS-R46	23	46.157	N	166	15.704	W	7*	90	60	60	15 to 26 feet deep - found one of Maragos' transects, double-pinned first pin and put in Transect B after his A
9/30/06	FFS	FFS 32	23	48.366	N	166	13.838	W	12	120	90	90	Followed the 25' contour all the way
9/30/06	FFS	FFS 33	23	50.188	N	166	16.010	W	12	0	0	0	Followed the 25' contour all the way

Table K.2. Log of permanent transect markers ("pins") installed in the Northwestern Hawaiian Islands by NOAA's Coral Reef Ecosystem and Hawaii DLNR DAR in September 2006. Pins were installed at 5-m intervals along each of 2-, 25-m transect lines (Transects A and B; 6 pins/transect). No pins were installed along Transect C. On each transect, pins #1, 2, and 6 are 3 m tall; pins 3, 4, and 5 are 2 m tall. GPS coordinates taken at beginning of Transect A. *permanent markers previously installed by Dr. Greta Aeby or Dr. Jim Maragos were used. ** pins were installed to replace those lost from previous Aeby/'Maragos installations. NR = not recorded; no compass available as survey was conducted by snorkel rather than SCUBA.

K.2 Benthic data

K.2.1 Algae

Table K.2.1.1. List and of algal samples collected during HI-0611. SPE under description code indicates scientific specimen. W under source indicates wild populations.

16a. Scientifc name	16b. Common name	17a. Foreign CITES Permit Number	17b. US CITES Permit Number	18a. Description Code	18b. Source	19a. Quantity/Unit (NO)	19b. Total Monetary Value	20. Country of Origin of Arrival
Amansia glomerata	None	n/a	n/a	SPE	W	2	$0	United States
Amphiroa spp.	None	n/a	n/a	SPE	W	2	$0	United States
Asparagopsis taxiformis	None	n/a	n/a	SPE	W	4	$0	United States
Boodlea composita	None	n/a	n/a	SPE	W	3	$0	United States
Bryopsis pennata	None	n/a	n/a	SPE	W	9	$0	United States
Caulerpa macrophysa	None	n/a	n/a	SPE	W	3	$0	United States
Caulerpa racemosa	None	n/a	n/a	SPE	W	1	$0	United States
Caulerpa peltata	None	n/a	n/a	SPE	W	1	$0	United States
Caulerpa serrulata	None	n/a	n/a	SPE	W	5	$0	United States
Caulerpa taxifolia	None	n/a	n/a	SPE	W	9	$0	United States
Caulerpa webbiana	None	n/a	n/a	SPE	W	8	$0	United States
Ceramium sp.	None	n/a	n/a	SPE	W	1	$0	United States
Chondria spp.	None	n/a	n/a	SPE	W	2	$0	United States
Chondrophycus parvipapillatus	None	n/a	n/a	SPE	W	3	$0	United States
Codium sp.	None	n/a	n/a	SPE	W	5	$0	United States
Coelanthrum	None	n/a	n/a	SPE	W	1	$0	United States
Dasy kristeniae	None	n/a	n/a	SPE	W	2	$0	United States
Dasya iridescens	None	n/a	n/a	SPE	W	11	$0	United States
Dictyopteris repens	None	n/a	n/a	SPE	W	1	$0	United States
Dictyota friabilis	None	n/a	n/a	SPE	W	1	$0	United States
Dictyosphaeria cavernosa	None	n/a	n/a	SPE	W	15	$0	United States
Dictyosphaeria versluysii	None	n/a	n/a	SPE	W	27	$0	United States
Dictyota spp.	None	n/a	n/a	SPE	W	18	$0	United States
Galaxaura spp.	None	n/a	n/a	SPE	W	7	$0	United States
Ganonema farinosum	None	n/a	n/a	SPE	W	4	$0	United States

16a. Scientifc name	16b. Common name	17a. Foreign CITES Permit Number	17b. US CITES Permit Number	18a. Description Code	18b. Source	19a. Quantity/Unit (NO)	19b. Total Monetary Value	20. Country of Origin of Arrival
Gibsmithia dotyi	None	n/a	n/a	SPE	W	4	$0	United States
Gibsmithia hawaiiensis	None	n/a	n/a	SPE	W	12	$0	United States
Halichrysis coalescens	None	n/a	n/a	SPE	W	1	$0	United States
Halimeda spp.	None	n/a	n/a	SPE	W	1	$0	United States
Halimeda discoidea	None	n/a	n/a	SPE	W	33	$0	United States
Halimeda distorta	None	n/a	n/a	SPE	W	2	$0	United States
Halimeda gracilis	None	n/a	n/a	SPE	W	2	$0	United States
Halimeda opuntia	None	n/a	n/a	SPE	W	28	$0	United States
Halimeda velasquezii	None	n/a	n/a	SPE	W	51	$0	United States
Halophila hawaiiana	None	n/a	n/a	SPE	W	1	$0	United States
Haloplegma duperreyi	None	n/a	n/a	SPE	W	9	$0	United States
Hypnea sp.	None	n/a	n/a	SPE	W	1	$0	United States
Kalymenia spp.	None	n/a	n/a	SPE	W	1	$0	United States
Laurencia gattsoffii	None	n/a	n/a	SPE	W	16	$0	United States
Laurencia sp.	None	n/a	n/a	SPE	W	18	$0	United States
Liagora pinnatum	None	n/a	n/a	SPE	W	2	$0	United States
Liagora spp.	None	n/a	n/a	SPE	W	9	$0	United States
Lobophora variegata	None	n/a	n/a	SPE	W	54	$0	United States
Martensia sp.	None	n/a	n/a	SPE	W	8	$0	United States
Microdictyon setchellianum	None	n/a	n/a	SPE	W	37	$0	United States
Nemastoma sp.	None	n/a	n/a	SPE	W	7	$0	United States
Neomeris sp.	None	n/a	n/a	SPE	W	29	$0	United States
Non-geniculate calcified branched red algae	None	n/a	n/a	SPE	W	36	$0	United States
Padina spp.	None	n/a	n/a	SPE	W	15	$0	United States
Peysonnellia spp.	None	n/a	n/a	SPE	W	15	$0	United States
Phyllodiction anastomosans	None	n/a	n/a	SPE	W	1	$0	United States
Plocamium sandvicense	None	n/a	n/a	SPE	W	3	$0	United States
Portieria hornemannii	None	n/a	n/a	SPE	W	1	$0	United States
Spyridia filamentosa	None	n/a	n/a	SPE	W	1	$0	United States
Stypododium flabelliformae	None	n/a	n/a	SPE	W	12	$0	United States

16a. Scientifc name	16b. Common name	17a. Foreign CITES Permit Number	17b. US CITES Permit Number	18a. Description Code	18b. Source	19a. Quantity/Unit (NO)	19b. Total Monetary Value	20. Country of Origin of Arrival
Tolypiocladia glomerulata	None	n/a	n/a	SPE	W	1	$0	United States
Trichogloea sp.	None	n/a	n/a	SPE	W	1	$0	United States
Trichogloeopsis sp.	None	n/a	n/a	SPE	W	1	$0	United States
Tricleocarpa sp.	None	n/a	n/a	SPE	W	1	$0	United States
Turbinaria ornate	None	n/a	n/a	SPE	W	8	$0	United States
Ventricaria ventricosa	None	n/a	n/a	SPE	W	1	$0	United States

K.2.2 Coral

Recent scientific expeditions in the Northwestern Hawaiian Islands (NWHI) have yielded several new records and possible species since the last compilation by Maragos et al. (2004) that covered surveys through 2002. In 2003, Greta Aeby and the author recorded a few new records, but during the 2006 NOWRAMP expedition several new records and possible new species have been reported. The REA team (Kenyon, Vargas) respectively reported new records of *Leptoseris incrustans,* and a possible new species of *Montipora,* at Pearl and Hermes Atoll. Kenyon also added new records of *Acropora valida* at Laysan and *Pavona maldivensis* at Maro. An exploratory team including Jim Maragos, Carl Meyer, and Yannis Papastamatiou made several deep water dives to 30 m off Lisianski Island/Neva Shoal and recorded several new records of deep water species: *Diaseris distorta*, *Cycloseris vaughani,* and other undetermined species of *Cycloseris,* and the soft coral *Sinularia.* Maragos also reported other new records at other islands and atolls. However, the most significant discoveries have resulted from the initial sightings by towboard scientists Jake Asher and Brian Zgliczynski of table coral *Acropora* off the southwest spur-and-groove habitat at Pearl and Hermes Atoll and off the shallow southeast forereef at Neva Shoals. These sightings were verified by the exploratory team and REA teams which confirmed the presence of *Acropora cytherea* and *A. cerealis-valida* at Pearl and Hermes and *Acropora valida* at Neva that led to other discoveries at Neva, a second *Acropora* and three *Montipora* species, all likely new to science.

The investigations through October 1, 2006 have yielded possibly seven new records for the NWHI with most likely new species, with the towboard scientists contributing directly or indirectly to many of the new records and species (Table 1). Despite the many stationary dives conducted in the NWHI since 2000, the informed observations of towboard scientists are more likely to yield additional new records and species during future expeditions. Their coverage during each dive is several orders of magnitude greater and includes coverage of the exposed north and eastern sides of all of the NWHI reefs. In contrast, the REA and monitoring teams need to focus on sites that can be assessed during all visits, which generally confines them to the west and south sides of most reefs and within much smaller discrete areas. Both of these strategies should continue to be used during future expeditions, with the addition of an exploratory team to follow up and verify the towboard discoveries by photography, focused observations, and collections of type specimens for new species.

Table K.2.2.1 gives the current listing of all coral and anemone species reported at the 10 NWHI and Raita Bank. As was the case during earlier compilations, the larger atolls with diverse habitat and shelter from large northwest swells support the greatest number of species. Additional dives to 30 m should fill the void of deeper water species records and yield a more informed assessment of the biodiversity of corals and anemones across the NWHI.

Table K.2.2.1. Distribution of corals and anemones reported in the NWHI during 1907–2006, Compiled by Maragos from Vaughan (1907), Dana (1971), Maragos et al. (2004), and the unpublished records of G. Aeby, J. Asher, J. Kenyon, J. Maragos, B. Vargas, and B. Zgliczynski. Asterisk (*) = undescribed or undetermined species. **Bold = species mostly at depths of > 30 m.**

Island	NIH	NEC	FFS	GAR	MAR	LAY	LIS	P&H	MID	KUR	RAI	# of isl.
stony corals												
Acropora cerealis			1	1	1							**3**
A. cytherea		1	1	1	1	1		1				**6**
A. gemmifera			1	1								**2**
A. humilis			1	1	1							**3**
A. nasuta			1		1	1						**1**
A. paniculata			1									**1**
**A.* sp.1 (prostrate)							1					**1**
A. valida			1		1	1	1	1				**5**
Montipora capitata	1	1	1	1	1	1	1	1	1	1	1	**11**
M. flabellate		1	1	1	1	1	1	1	1	1		**9**
M. patula	1	1	1	1	1	1	1	1	1	1		**10**
**M.* sp.4 cf. *incrassata*		1	1		1					1		**4**
M. dilatata						1	1					**2**
**M.* sp.6 cf. *dilatata*					1							**1**
**M.* sp.7 (foliaceous)							1	1	1			**3**
**M.* sp.2 (ridges)								1		1		**2**
**M.* sp.5 (branching)							1					**1**
**M.* sp.14 (nodular) Vargas								1				**1**
M. tuberculosa			1		1	1	1	1	1	1		**7**
**M.* sp.3 cf. *turgescens*					1	1	1	1	1	1		**6**
M. verrilli			1		1	1	1	1	1	1		**7**
Gardineroseris planulata									1			**1**
Leptoseris hawaiiensis						1						**1**
L. incrustans			1					1	1	1		**4**
L. scabra			1				1					**2**
Pavona clavus								1	1	1		**3**
P. duerdeni	1	1	1	1	1	1	1	1	1	1		**10**
P.maldivensis			1		1		1	1	1	1		**6**
P. varians	1	1	1	1	1	1	1	1	1	1		**10**
**Balanophyllia* sp. (pink)			1		1					1		**3**
Cladopsammia eguchii			1	1	1	1		1	1	1		**7**
Tubastraea coccinea	1		1	1	1	1		1	1	1	1	**9**
Cyphastrea ocellina	1	1	1	1	1	1	1	1	1	1		**10**
Leptastrea agassizi			1		1				1			**3**
L. bewickensis			1				1	1				**3**
L. purpurea	1	1	1	1	1	1	1	1	1	1		**10**
L. pruinosa		1	1	1	1							**4**
**L.* sp.8 cf. *F. hawaiiensis*		1	1		1		1			1		**5**
***Cycloseris* sp.9 (equal septae)**				1			1	1				**3**

Island	NIH	NEC	FFS	GAR	MAR	LAY	LIS	P&H	MID	KUR	RAI	# of
C. vaughani							1	1	1			**3**
Diaseris distorta							1					**1**
Fungia scutaria	1		1	1	1	1	1	1	1	1		**9**
F. granulose					1	1		1				**3**
Pocillopora damicornis			1		1	1	1	1	1	1	1	**8**
P. eydouxi	1	1	1	1	1	1	1	1	1			**9**
P.* sp.10 cf. *laysanensis						1				1	1	**3**
P. ligulata	1	1	1	1	1	1	1	1	1	1	1	**11**
P. meandrina	1	1	1	1	1	1	1	1	1	1		**10**
P. molokensis	1		1	1	1	1	1	1		1	1	**9**
P. cf. *verrucosa*							1	1				**2**
**P.* sp.11 cf. *capitata*			1		1	1	1	1	1	1	1	**8**
**Porites* sp.12 cf. *annae*							1	1		1		**3**
Porites brighami	1	1	1	1	1	1	1	1		1		**9**
P. compressa	1	1	1	1	1	1	1	1	1	1	1	**11**
P. duerdeni		1	1	1	1			1		1		**6**
P. evermanni	1	1	1	1	1	1	1	1	1	1		**10**
P. hawaiiensis		1	1	1	1	1	1	1	1	1		**9**
P. lobata	1	1	1	1	1	1	1	1	1	1		**10**
P. rus					1							**1**
**P.* sp.13 cf. *solida*				1		1		1	1	1		**5**
Psammocora explanulata				1								**1**
P. nierstraszi		1	1	1	1	1	1	1	1			**8**
P. stellata	1		1	1	1	1	1	1	1	1	1	**10**
P. verrilli								1	1	1		**3**
non-stony corals & anemones												
Palythoa tuberculosa	1	1	1	1	1	1	1	1	1	1		**10**
P. sp.			1									**1**
Zoanthus pacifica			1		1			1		1		**4**
Zoanthus sp (Kure)										1		**1**
Zoanthus sp ("B")	1	1	1		1		1					**5**
**Sinularia sp* (yellow)	1	1	1	1			1					**5**
**Sinularia (*purple*)*				1						1		**2**
**Sinularia* (brown)			1									**1**
***Sinularia* (pink)**								1				**1**
Acabaria bicolor			1							1		**2**
Cirrhipathes sp	1											**1**
Heteractis malu			1	1	1	1				1		**5**
total species per island	**21**	**24**	**51**	**33**	**44**	**35**	**41**	**46**	**34**	**42**	**9**	

total species of stony corals: 64
total for all cnidarians: 76

K.3 Fish

K.3.1. Top predator surveys

This phase of our project focused on retrieving top predator movement data from acoustic receivers previously deployed throughout the Northwestern Hawaiian Islands Marine National Monument (NWHIMNM), and deploying additional receivers to fill gaps in our listening array. We successfully recovered, downloaded, and redeployed 17 receivers. One receiver (Mokumanamana Island) was missing and was not replaced because of the risk of losing additional receivers in the high energy environment at the designated deployment site. To date, our acoustic receivers have recorded 372,577 detections of 99 top predators that were equipped with acoustic transmitters in NWHIMNM waters in 2005 and 2006. Preliminary analyses indicate that tiger sharks (*G. cuvier*) are the most wide-ranging top predator in the NWHIMNM with 5 of 16 transmitter-equipped individuals detected moving between atolls and islands. One tiger shark tagged at Pearl and Hermes Reef in September 2005 was subsequently detected on the Kona coast of Hawaii Island, having traveled a minimum distance of 2,250 km. A single gray reef shark (*C. amblyrhynchos*) was detected moving between Kure, Midway, and Pearl and Hermes Atolls. To date, we have not detected any interisland movements by Galapagos sharks (*C. galapagensis*) or teleosts (*C. ignobilis* and *Aprion virescens*). However, all six top predator species ranged widely within individual atolls, although for most teleosts these movements were occasional, atoll-spanning excursions from within smaller core areas that were utilized most of the time. Both ulua (*C. ignobilis*) and uku (*A. virescens*) exhibited well-defined patterns of movement with distinct diel, seasonal, and lunar components. In contrast, most sharks did not exhibit any clear patterns of movement.